

1908.

WESTERN AUSTRALIA.  
*With the Government Geologist's  
Compliments*  
GEOLOGICAL SURVEY.

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REPRINT OF BULLETINS 15, 20, & 23.

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THE GEOLOGICAL FEATURES  
AND  
MINERAL RESOURCES OF THE  
PILBARA GOLDFIELD.

BY

A. GIBB MAITLAND,

GOVERNMENT GEOLOGIST.

WITH AN APPENDIX BY A. MONTGOMERY, M.A., F.G.S.  
STATE MINING ENGINEER.

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*Re-issued under the authority of the Hon. H. GREGORY, M.L.A.,  
Minister for Mines.*

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WITH TWENTY MAPS AND SIXTY-THREE FIGURES.

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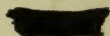
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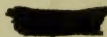
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The Hon. Sir Gregory M. L. A.  
Minister of Mines

GEOLOGICAL SKETCH MAP

# THE PILBARA GOLDFIELD

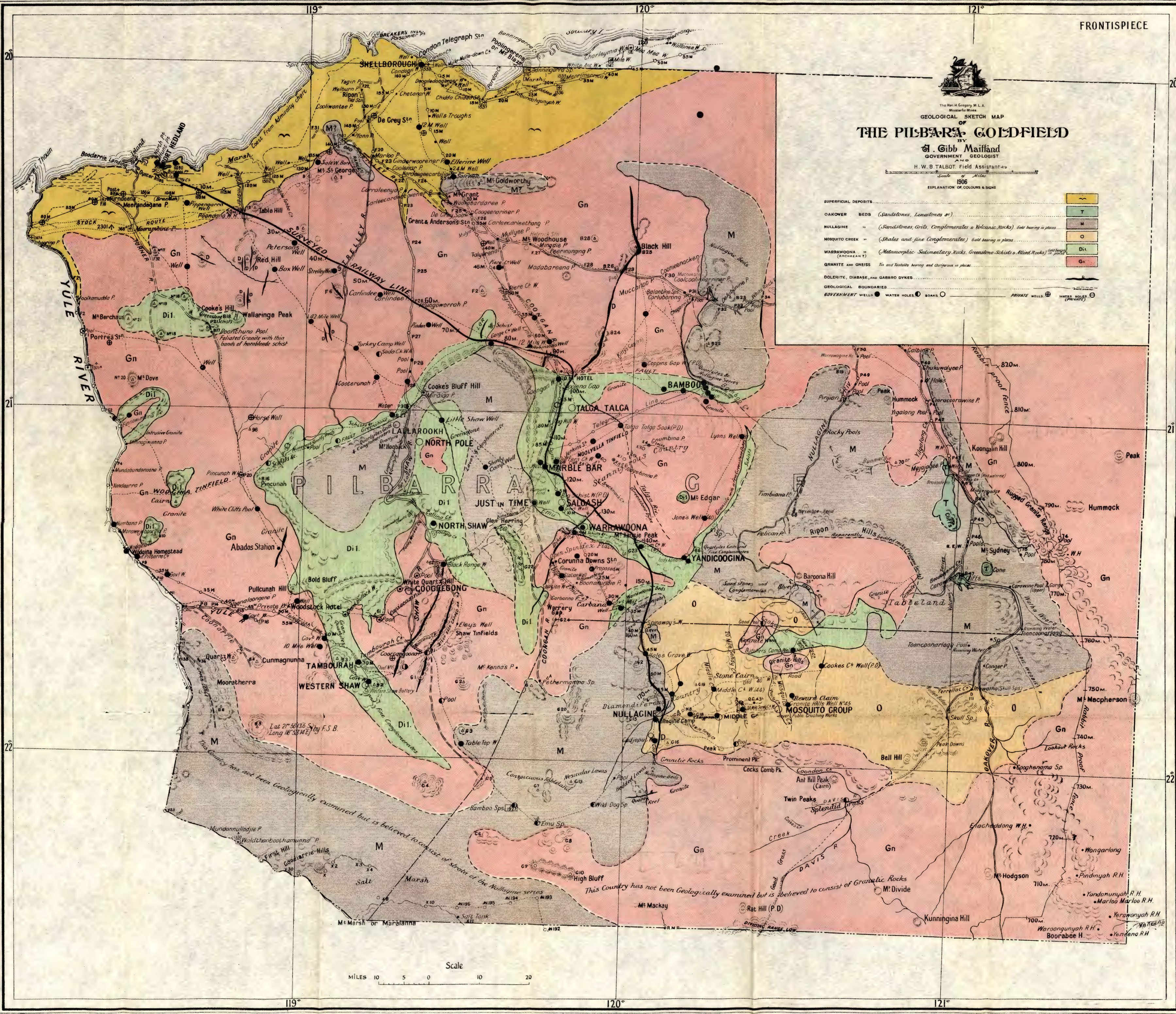
G. Gibb Maifland  
GOVERNMENT GEOLOGIST

H. W. B. TALBOT, Field Assistant

Scale of Miles  
1906

EXPLANATION OF COLOURS & SIGNS

- SUPERFICIAL DEPOSITS:
- OAKOVER BEDS (Sandstones, Limestones &c.)
  - NULLAGINE " (Sandstones, Grits, Conglomerates & Volcanic Rocks) Gold bearing in places
  - MOSQUITO CREEK " (Shales and fine Conglomerates) Gold bearing in places
  - WARRAWOONA " (Metamorphic Sedimentary Rocks, Gneiss, Schists & Allied Rocks) Gold bearing in places
  - GRANITE AND GNEISS Tin and Tantalite bearing and Quartz veins in places
  - DOLERITE, DIABASE, AND GABBRO DYKES
  - GEOLOGICAL BOUNDARIES
  - GOVERNMENT WELLS WATER HOLES SOAKS PRIVATE WELLS



Lat 21° 56' 36" S by F.S.B.  
Long 118° 38' 12" E

This Country has not been Geologically examined but is believed to consist of Granitic Rocks

Scale  
MILES 10 5 0 10 20





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1908.

WESTERN AUSTRALIA.

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## PREFATORY NOTE

OWING to the demands on the part of the General Public for copies of the three Bulletins, Nos. 15, 20, and 23, the Government decided upon reprinting them in one volume, along with the Report of the State Mining Engineer, in order that all the official data upon the district might be brought together in a handy form under one cover.

Only such alterations have been made in the text of the original Reports as have been necessitated by the use of one volume in lieu of three for the publication.

The Gold Mining Statistics differ from those in the State Mining Engineer's Report, which forms Appendix III., in that, in the latter, the figures give the yield in ounces of fine gold, but owing to the shortness of time available for republication it has not been found possible to reduce the former tables to fine ounces also.

During the progress of the fieldwork I was assisted throughout by Mr. H. W. B. Talbot, Field Assistant, to whose co-operation the comparatively rapid completion of the field maps was in no small measure due.

A. GIBB MAITLAND,  
*Government Geologist.*

GEOLOGICAL SURVEY OFFICE, PERTH,  
10th February 1908.



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# Geological Features and Mineral Resources of the Pilbara Goldfield

## DIVISION I PRELIMINARY REPORT, 1903

### INTRODUCTION

THE Pilbara Goldfield is situated in latitude 21 degrees south, and is, with the exception of Kimberley and Yilgarn, the oldest and perhaps the least known of any of the mining fields of Western Australia.

It is bounded, as defined by the authorities, by :—

“a line starting from a point on the sea-coast eastward from Condon Creek and extending through the summit of Poolingerena (or Mount Blaze) to a spot due north from the summit of Mount Macpherson ; then south through the said summit to a spot due east from the summit of Mount Marsh, on the Upper Fortescue River ; thence due west through the summit of Mount Marsh to the right bank of the Fortescue River, along it downwards to Survey Station V 23 ; thence in a northerly direction through Survey Station V 32 to the right bank of the Cocreaca branch of the Yule River, and along the right banks of the Cocreaca Creek and the Yule River downwards to the sea-coast, and along the sea-coast eastward to the starting-point ; excluding all town sites within the said boundaries.”

The area included within these boundaries embraces about 34,880 square miles.

Prospecting has been carried out in the Pilbara District since the year 1877, but serious mining operations can scarcely be said to have yet begun.

The gold yield of the field, as reported to the Department of Mines up to the end of 1903, has been 119,383·34 ozs., obtained from the milling of 54,883·95 tons of ore, thus giving an average yield of 2·17 ozs. per ton.

The following table gives the yield of the field up to the close of the past year, as shown by (*a*) the figures furnished to the Department of Mines, and by (*b*) the data in the archives of H.M. Customs House and the Perth Mint. It will be noticed that in almost every case there is a difference between the two sets of figures. Up to the end of 1903 there have been officially reported to the Mines Department 119,383·34 ozs. of gold from the different centres ; the Customs and Mint authorities, however, give the gross weight of 208,810·39 ozs. (with a fine gold content of 185,886·47 ozs.)

being 89,427·05 ozs. in excess of the figures furnished to the Mines Department. This discrepancy may perhaps be accounted for by the difficulty experienced in obtaining a record of the alluvial gold, and also by the fact that a good deal of the gold won in the early days was probably never officially reported. In addition to the gold, there has also been raised, up to the close of the year 1903, 1,442·26 tons of tin ore, valued at £92,984.

*Table showing the Yield of the Pilbara Goldfield.*

I. GOLD YIELD.

Year.	Ore Crushed.	Yield of Gold therefrom.	Gold Exported and received at the Perth Mint.		Remarks.
			Gross Weight.	Fine Contents.	
	Tons.	Ozs.	Ozs.	Ozs.	
1889	11,121·10	a 28,470·56	b11,170·00	9,992·63	a. Includes 2,082 ozs. from unknown tons b. Includes export from West Pilbara
1890			b16,055·31	14,363·01	
1891			b11,875·00	10,623·32	
1892			b12,892·80	11,533·84	
1893			b11,698·50	10,465·43	
1894			b16,254·50	14,541·20	
1895			b19,522·40	17,464·65	
1896			b11,810·11	10,565·27	
1897	5,138·70	6,825·26	b11,955·87	10,695·67	c. Includes 2,000 ozs. of alluvial and 102 ozs. dollied and specimens
1898	6,719·75	c 14,413·79	11,662·56	10,433·27	
1899	7,567·55	d 19,291·98	20,526·20	18,362·65	d. Includes 2,608·29 ozs. alluvial and 833·72 ozs. dollied and specimens
1900	6,173·71	e 16,616·85	17,140·51	15,333·82	e. Includes 1,527·54 ozs. of alluvial and 88·92 ozs. dollied and specimens
1901	5,414·11	f 10,264·32	11,320·40	10,260·43	f. Includes 1,050·55 ozs. of alluvial and 275·52 ozs. dollied and specimens
1902	7,163·38	g 12,170·46	10,706·03	9,199·50	g. Includes 679·05 ozs. of alluvial and 41·37 ozs. dollied and specimens
1903	5,585·65	h 11,330·12	14,220·20	12,051·78	h. Includes 1,180·48 ozs. of alluvial and 741·97 ozs. dollied and specimens
Total	54,883·95	119,383·34	208,810·39	185,886·47	



*Table showing the Yield of the Pilbara Goldfield.*

II. TIN YIELD.

Year.	Ore Raised.	Value thereof.
	Tons.	£
Previous to 1899 .	75·45	4,419
1899 . . . . .	57·50	3,612
1900 . . . . .	387·87	27,174
1901 . . . . .	412·98	21,148
1902 . . . . .	216·35	15,103
1903 . . . . .	292·11	21,528
Total . . . . .	1,442·26	92,984

## PART I.—GENERAL GEOLOGY

### SECTION I.—THE SALIENT GEOLOGICAL FEATURES

AN account of the geology and mineral resources of the district was given by Mr. H. P. Woodward in the years 1888<sup>1</sup> and 1890.<sup>2</sup> In this latter report it was set forth that—

in a country of this description a more or less detailed geological survey would be of very great assistance to the diggers . . .

At a later period, Mr. S. J. Becher, who acted as Inspector of Mines, supplemented the data acquired by Mr. Woodward,<sup>3</sup> and added somewhat to our meagre stock of knowledge.

Mr. R. Neil Smith, a Mining Engineer, employed by the Department, dealt in an official report with a portion of the district, and added a few facts to the scanty knowledge of Pilbara.<sup>4</sup>

To carry out a complete geological examination of a tract of country so extensive, in the space of time that it was possible to devote to the work, was found to be quite impossible. In a reconnaissance carried out along the main roads or tracks—where no small portion of a geologist's time is occupied in overcoming the difficulties of the route and locating positions—it will readily be understood how impossible it is to acquire much knowledge of minute details.

The present report may be regarded as the first result of an attempt at a systematic and reasonably detailed examination of the broader geological features of the district, in so far as they have any bearing upon economic questions; it refers exclusively to but a small portion of the field. The report includes particulars with reference to the mining centres of Lalla Rookh, North Pole, Talga Talga, Moolyella, Bamboo, Elsie Creek, Boodalyerri, Mosquito, Sandy and Middle Creeks. An attempt has been made to sum up the existing knowledge of the district; but while by far the greater portion of the report is the direct result of my own personal observations, the manuscript reports of the Inspectors of Mines have been laid under contribution when considered necessary. The report is accompanied by a series of geological maps and sections which, in some measure, serve to make the descriptions a little more intelligible.

<sup>1</sup> H. P. Woodward. Annual General Report for 1888-9. Perth: By Authority, 1890, pp. 35-37.

<sup>2</sup> H. P. Woodward. Annual General Report for the year 1890. Perth: By Authority, 1891, pp. 22-35.

<sup>3</sup> S. J. Becher. Report on the Pilbara Goldfield, 1894-5, with reference to its Geological Character. Appendix 5. Report of the Department of Mines for the year 1895. Perth: By Authority, 1896.

<sup>4</sup> S. J. Becher. Report on the Northern Goldfields. Report of the Department of Mines for the year 1896. Perth: By Authority, 1897.

<sup>5</sup> R. Neil Smith. The Probability of obtaining Artesian Water between the Pilbara Goldfields and the Great Desert. Geological Survey, Bulletin No. 2. Perth: By Authority, 1898.

The district affords better and more continuous sections than are generally to be met with on any of the goldfields of the State which have yet been examined; they thus reveal geological structures which are not to be found in the more southerly districts, and on this account serve to throw light on many obscure points in connection with the geology of other fields.

What are believed to be the oldest rocks occurring in Pilbara are the granites and gneisses, which form the platform upon which the newer formations were laid down, and which everywhere underlie the great plain extending from Port Hedland to Doolena Gorge, on the Shaw River.

To these succeed the greenstone schists and allied rocks, which occupy an extensive area of country, and which appear to be almost everywhere genetically connected with the occurrence of gold. These schists are associated with laminated, sometimes hematite-bearing, quartzites, which may merely represent silicified schists, the silicification having taken place along certain areas to such an extent as to make the rocks resemble fine-grained sedimentary quartzites. The rocks of the greenstone schist series have not been closely studied microscopically, but some, at any rate, appear to owe their origin to the transmutation of eruptive rocks. There are, however, associated with them beds of undoubted sedimentary origin.

Next in antiquity to the greenstone schists comes the series of sandstones, grits, conglomerates, thin limestones, sometimes magnesian, and associated volcanic rocks, so well exposed in many portions of the district. For convenience of description, these will be referred to as the Nullagine Beds. This formation, the actual base of which is rarely seen, forms an important feature in the geology of Pilbara, and none plays so prominent a part in the landscape. The Nullagine Beds cannot be exactly correlated with those yet described in any of the previous official reports on the geology of Western Australia. In their lithological characters and general behaviour they resemble very strongly the quartzites, &c., which form that continuous formation extending from Wyndham to Mount Hart, a prominent summit on the King Leopold Range, in Kimberley, to which reference has been made in a former report.<sup>1</sup>

If a comparison between two regions, separated by about five degrees of latitude, be of any value in correlating strata, then there seem to be very strong reasons for identifying the two series of beds. On the strength, therefore, of the lithological and structural similarity to those of the Leopold Range, the Nullagine Beds are assumed to be of the same age, viz., Cambrian; but in view of the deficiency of our knowledge of these beds, it is obvious that this assumption is more or less guesswork.

Above the Nullagine Beds come the sandstones, limestones,

<sup>1</sup> Annual Progress Report of the Geological Survey for the Year 1901. Perth: By Authority, 1902, pp. 8-9.

cherts, &c., which form the table-topped hills in the vicinity of the Oakover River. These do not, so far as has yet been noticed, occupy any very extensive area of country, nor are they very thick. They will be referred to as the Oakover beds.

The following is the geological record, arranged in the form of a table, as furnished by that portion of the Pilbara Goldfield so far examined:—

Recent . . . . .	Blown sand. Alluvium of the river beds. Residual Deposits (sands, laterite, &c.).
Tertiary (?) . . . . .	Oakover Beds (sandstones, limestones, &c.).
Cambrian (?) . . . . .	Nullagine Beds (sandstones, grits, conglomerates, limestones, and volcanic rocks).
Archæan (?) . . . . .	Greenstone Schists and allied rocks ( <i>gold-bearing rocks</i> ). Granites and Gneisses ( <i>tin-bearing rocks</i> ).

In addition to the beds above mentioned, a series of igneous rocks have invaded the schists, gneisses, and granites in the form of dykes, which run in long approximately parallel lines. The dykes, which are all basic compounds, often form very conspicuous features in the landscape, owing principally to their black weathered summits, which stand out in bold relief. Mr. F. T. Gregory, in his Journal of the North-West Exploring Expedition in 1861, when traversing that portion of the country now embraced by the Pilbara Field, often described these dykes as “black volcanic ridges” protruding through the crystalline schists and allied rocks. Wherever good sections can be seen of these dykes they invariably have a tendency towards verticality, but do not attain any very great width. So far as any observations have at present been carried, these dykes have no apparent connection with any deep-seated rock of similar composition. Whatever may be the exact age of these dykes, it is quite clear that they are of later date than the first foliation which affected the crystalline schists and allies, and of greater antiquity than that of those faults which almost invariably mark the junction between the Nullagine Beds and the older rocks. These dykes have been nowhere seen to pierce the Nullagine Beds.

The different formations, however, will not be described in any definite order, but a general description of the sections seen in the vicinity of the route followed will be given, as being perhaps of greater convenience.

The exigencies of the Department prevented any petrographical work in connection with the rocks of Pilbara being carried out, but a series of rocks have been sliced. As opportunity offers, it is hoped they will be microscopically examined and included in the report upon the other portion of the district yet to be examined. With this in view, a series of chemical analyses of some of the typical rocks have been made, and the result of these are given in the following table:—



*Table of Analyses of Rocks from Pilbara.*

Geological Museum No.	5426	5395	5397	5392	5404	5384	5405	5375
Specific Gravity . . .	2.71	2.69	2.64	2.69	2.67	2.77	2.79	2.69
Silica, SiO <sub>2</sub> . . . . .	63.08	69.97	68.36	72.77	70.92	54.41	53.85	38.91
Alumina, Al <sub>2</sub> O <sub>3</sub> . . . . .	15.10	18.74	18.74	13.87	12.77	12.80	14.00	1.08
Ferric Oxide, Fe <sub>2</sub> O <sub>3</sub> . . .	1.72	1.04	nil	trace	trace	.16	.36	10.30
Ferrous Oxide, FeO . . . .	4.45	.43	1.15	2.79	4.62	10.35	8.12	1.80
Magnesia, MgO . . . . .	2.67	.81	.54	.40	.33	5.72	4.51	36.65
Lime, CaO . . . . .	2.83	.15	.39	1.60	1.46	5.21	6.43	trace
Soda, Na <sub>2</sub> O . . . . .	4.37	.59	10.22	4.18	3.32	3.02	3.14	.40
Potash, K <sub>2</sub> O . . . . .	3.86	5.82	.07	2.81	3.92	.02	.60	trace
Combined Water H <sub>2</sub> O . . .	.58	1.79	.03	.29	.54	3.42	2.94	10.89
Hygroscopic Water H <sub>2</sub> O . .	.10	.05	nil	.02	.08	.15	.06	.28
Carbonic Anhydride, CO <sub>2</sub> . .	.11	nil	...	.24	.85	3.58	4.37	nil
Titanic Oxide, TiO <sub>2</sub> . . . .	.68	.64	...	.55	.56	.78	.55	.06
Pyrites, FeS <sub>2</sub> { Fe . . . .	.08	...	...	trace	.05	...	nil	nil
{ S . . . . .	.09	...	...	trace	.05	...	nil	nil
Manganese Protoxide, MnO	.23	trace	.45	.22	.17	.09	.87	.08
	99.95	100.03	100.02	99.74	99.64	99.71	99.80	100.45

5426.—Granite. Mosquito Creek, Pilbara Goldfield. Analyst, J. H. Brooking.

5395.—Altered Granite (lodestuff). Boodalyerri, Pilbara Goldfield. Analyst, E. S. Simpson.

5397.—Pegmatite (tin matrix). Moolyella, Pilbara Goldfield. Analyst, E. S. Simpson.

5392.—Porphyry. Duffer's Creek, near Marble Bar, Pilbara Goldfield. Analyst, J. H. Brooking.

5404.—Quartz Felsite. Bamboo Creek, Pilbara Goldfield. Analyst, E. S. Simpson.

5384.—Andesite. North Pole, Pilbara Goldfield. Analyst, C. C. Williams.

5405.—Greenstone (dolerite). Bamboo Creek, Pilbara Goldfield. Analyst, C. C. Williams.

5375.—Serpentine. Hills near Box Soak, Pilbara Goldfield. Analyst, E. S. Simpson.

## SECTION II.—TOPOGRAPHY

By far the major portion of the Pilbara Field is, as may be seen by the official maps, drained by the De Grey River and its numerous tributaries.

Some confusion having apparently arisen in respect to the nomenclature of the De Grey and its tributaries—the Davis and the Oakover—as shown on the existing maps, it may perhaps be appropriate to briefly note the facts in so far as may be ascertained by a reference to the original sources.

On the 26th of August of the year 1861, Mr. F. T. Gregory,



the Commander of the North-West Australian Expedition, left his 67th camp in south latitude 21 degrees 20 minutes 13 seconds, east longitude 120 degrees 17 minutes, which lies some miles to the north-east of what is now the mining centre of Yandicoogina. This creek was traversed for 5 miles through the hills, until

"it joined a river coming from the southward, one hundred yards wide, which was followed down on an average course of east-north-east to latitude 21 degrees 18 minutes,"<sup>1</sup>

where his 68th camp was pitched.

The following day, 27th August, the Commander's diary states—

"the river took us on a northerly course nine or ten miles, receiving many large tributaries, several of them still running slightly, forming altogether a stream of some importance, which, on account of the large extent of pastoral and agricultural lands afterwards found on its banks lower down, and its many fine tributaries, I named the De Grey, in honour of the noble lord who took a lively interest in promoting the objects of the Expedition."<sup>1</sup>

The positions of these numbered camps are properly located upon the latest map of the State, issued by the Department of Lands, and the course of the river below delineated.

As the result of a traverse by myself down the Nullagine River from where it is crossed by the main road from Yandicoogina to the Elsie Diggings, it has been proved that the De Grey River and the Nullagine are one and the same. In view of this, having due regard to the question of priority of nomenclature, it is desirable that Gregory's name of De Grey should be retained for the whole river, from its mouth to its source.

Leaving the De Grey River on the 27th of August 1861, Commander Gregory travelled generally eastward, and on the 29th inst.

"came upon a river 200 yards wide, running to the northward. The long drought had reduced it to a few shallow pools, running from one to the other through the deep sand in the bed."

The following day the exploring party

"followed the river up for seven or eight miles, through fine open forest country, and encamped near a deep pool. . . . This river was named the Oakover. Camp 72."

On the 11th of September the party

"fell back five or six miles across the ranges to a tributary of the Oakover, called the Davis ;"

which was followed down to its junction with the Oakover. The position of the Davis River (of Gregory) and camp 78 is shown on the plan of the Pilbara and West Pilbara Goldfields, No. 151, issued by the Department of Mines in 1903. The same plan, however, shows another important tributary called Davis River, rising to the south of Bell Hill, lat. 22 degrees, and entering the Oakover at Carawine Pool, P 47.

On the 28th of October 1903, I visited the Oakover River at

<sup>1</sup> Journals of Australian Explorations, by A. C. Gregory and F. T. Gregory, North-West Coast, 1861. Reprint, Brisbane Government Printer, 1884, pp. 78-79.

Carawine Pool, and from the summit of a high tableland on the eastern bank of the river obtained an excellent view of the valley of the Davis River (of Gregory), both up and down its course. It appears, therefore, that there are two Davis Rivers, one in the east and another in the west, entering the Oakover River above its junction with the De Grey, and it is perfectly clear that "the Davis River" flowing past Skull Spring is not identical with the Davis River as originally located by Gregory in 1861.

It may possibly be regarded as a matter of small moment what name should be given to the Nullagine and the De Grey, it being merely a question of priority of nomenclature *versus* use, but there can be no valid reason for attempting to substitute the old established name of the Davis for a new river entering the Oakover on its western side, some miles above Carawine Pool.

It is highly desirable that at any rate the principal water-courses in mining and other districts should be traversed and their position accurately laid down upon the published maps.

A very important and most marked topographical feature in the Pilbara Goldfield consists of those gorges or gaps through which practically all the rivers flow before reaching the coastal plain on their way to the sea. Wherever an opportunity was presented for examining these gorges they were found to form very narrow passes, with almost vertical walls rising to considerable heights above their base. An excellent section of one of these is shown in Fig. 5 on a later page. These gorges vary greatly in length, some giving an actual measurement of 1500 feet. Many of the watercourses, after flowing along the strike of the jaspers, &c., which invariably forms these gaps, suddenly change their course and cross the ridges at right angles. Pools of water invariably occur in the recesses of these gorges. The gaps would seem to owe their origin to the circumstance that erosion practically kept pace with the rate at which the surface of the land rose.

### SECTION III.—DESCRIPTIVE GEOLOGY

#### A.—The Country between Port Hedland and the Shaw River

The first appearance of the granitic rocks is in the bed of Pippingarra Creek, at no great distance from Port Hedland, where they weather into the characteristic sandy soil which occupies such an extensive area between the coast and what may for convenience be called the Main Range.

In the neighbourhood of Poondana Waterhole on Petermarrer Creek, the granitic gneiss is seen to be intersected by greenstone dykes, which, wherever any sections are exposed, seem to be either vertical or inclined at high angles. Near the northern face of Poondana Hill are two vertical quartz reefs, about ten or twelve feet apart, which have a general strike of 13 degrees. The eastern-

most of the two rises a few feet above the surface like a wall, and is about five feet thick. The reef is traversed by horizontal and vertical joints, which cause it to break up into cubical blocks, like courses of masonry. Certain portions of the granitic gneiss rise as low bare knobs to heights about a foot or two above the general level of the surrounding country, and in one locality in the vicinity of Pippingarra numerous small crystals of tourmaline strew the surface and also occur in the country rock itself. They suggest the possibility of tin occurring in the vicinity, more especially as tin is actually being obtained from the same formation in other portions of the field.

From our camp at Box Soak, on a small creek flowing north, at a point on the (unsurveyed) road from Poondana to Lalla Rookh, almost due east of the Red Hill Trig. Station No. 10, a short traverse was made of the surrounding country, with the object of gaining a wider knowledge of its characteristics.

About a mile west of the camp, granite occupies the country as far as a low quartz ridge, the summit of which is about 140 feet by aneroid above camp. The reef has a general strike of 213 degrees, and is vertical; parallel to it on the east is another similar reef, about fifty feet distant. Neither of these two contain any minerals of commercial importance. About half a mile farther east a very conspicuous greenstone dyke, striking 18 degrees 30 minutes, and standing like a wall of masonry, can be followed across country for a considerable distance. Farther to the eastward the granite is traversed by pegmatite veins (? dykes).

The place of the granitic series is taken by schistose and other metamorphic rocks, about 200 chains from the camp. The actual width and extent of this band was not ascertainable. Near the contact between the granite and the schists, hornblende schist [5377]<sup>1</sup> makes its appearance, and sections in other portions of the neighbourhood seem to indicate that this is merely a transmuted portion of a coarse massive hornblende rock. A bed of a serpentinous rock [5376] of obscure origin occupies a small area near the junction of the granite with the schist; the rock is distinctly banded (? foliated), the general strike of the bands being 45 degrees; it contains crystals of felspar (?). The bands (or foliation planes) are inclined at a high angle to the east, conforming in this respect to that of the neighbouring schists. The serpentinoid rocks weather to a characteristic whitish brown colour. An analysis of a massive variety [5375] is shown in the table of analyses, page 7.

About five or six miles east of the Box Soak Camp is a long narrow serrated ridge, rising to a height of about 300 feet above the plains and having a general bearing of 223 degrees 30 minutes. This ridge is composed of a laminated iron-bearing jasper of the type common to many of the other goldfields of the State. The

<sup>1</sup> The figures in heavy type [5377] throughout the report refer to the numbers of the specimens as entered in the Departmental Collection Register.



band is about 50 feet in width, and the laminae are minutely puckered along its central portion, pointing to a movement, allied to shearing, along the trend of its outcrop. This band of jasper (chert) can be traced across country along a sinuous course for several miles. It seems quite clear that this long sinuous ridge occurs along a main line of fault. A somewhat softish banded acidic rock, containing easily recognisable felspar crystals, forms the western wall of the jasper. The eastern side of the ridge exposes a few feet of greenstone schist, which gradually gives place to gneissic granite, foliated in a direction of N. 26 degrees E., the planes of foliation being vertical.

Between Box Soak Camp and Red Hill (Trig. Station 10) the country is occupied by granite, intersected by many conspicuous quartz reefs and greenstone dykes. Near the summit of Red Hill, the general bearing of these dykes is about 13 degrees. Red Hill owes its name to the characteristic reddish colour to which the rock weathers. A conspicuous quartz reef forms a bold outcrop about three-quarters of a mile east of the summit. The reef is several feet thick, and forms the summit of a serrated ridge, which can be followed across country for about two miles. The reef is vertical, and is of milkish white quartz, apparently barren. The average strike of the reef is 223 degrees. There are, in addition to a long arm of the main reef joining it on the west with an average strike of 234 degrees, two other reefs of lesser dimensions and horizontal extent, lying parallel to it on the west, but a few yards distant. They evidently all belong to the same fracture system.

Practically the whole of Pippingarra Creek drains country underlaid by granitic and allied rocks. A very conspicuous granite hill, Trig. Station '4, is traversed by a coarse greenstone dyke, trending generally 105 degrees, and of considerable horizontal dimensions, though nowhere very thick, and apparently vertical. From this point to Cook's Hill, on the south bank of the Turner River, the whole country is occupied by granite. This, however, gives place to slaty and schistose rocks at a point about 15 chains from the river bank. Cook's Hill is the crowning point of a low ridge of laterite, resting upon the upturned edges of the slaty rocks, which are traversed by veins of ironstone.

Close to Cook's Hill, and bearing from it 171 degrees, and distant about half a mile therefrom, are a series of old abandoned shafts, known as the Kobelanna workings. Those expose a series of fine-grained and almost vertical slaty rocks, striking 193 degrees, and underlying slightly to the east. So far as may be seen, the slates are traversed by thin, irregular veins of ironstone and quartz, which may have yielded a little gold to the original prospectors. The veins appear to lie along the laminae of the slaty rocks.

About 300 chains farther up the Turner River, at Poonthanna Pool, near B 17, the channel is dammed by a bar of banded chert, which forms the conspicuous ridge on either side of the river. The pool is a fine deep sheet of water, which is apparently per-

manent. At the pool the section shows the bar to consist of a finely banded jasper or chert [5378], which is vertical. The central portion of the band is formed of a breccia of about 12 inches in thickness, consisting of angular fragments of the chert, recemented by quartz and oxide of iron. Horizontal faulting is also visible in the cliff section. The general strike of the ridge is 251 degrees.

About a mile to the south of B 17 the place of schists is taken by a finely foliated granite, the planes of foliation being approximately parallel to the general strike of the chert or quartzite.

Wallaringa Peak, a narrow isolated ridge rising to a height of 320 feet above the level of Poonthanna Pool, occurs in the same belt of schists. The sections exposed show the hill to be made up of decomposed vertical schists, striking 37 degrees.

There are strong stratigraphical reasons for believing that the belt of schistose rocks which cross the Turner at Kobelanna and Poonthanna Pool forms the continuation of that described as occurring to the east of the Box Soak Well. There is every reason to believe that a little gold, at any rate, may be found by carefully prospecting over the area occupied by this belt of greenstone schists and its allies.

Between Box Soak and the Strelley (?) Well, lying about south of Trig. Station No. 6, the country is underlaid by granitic gneiss of the prevailing type.

A traverse from the camp at this well, as far north as No. 6 Survey Station, over gently undulating country, demonstrated that the staple formation consisted of a rudely foliated granite, intersected by dykes (?) or veins of pegmatite.

The hill upon which Trig. Station No. 6 rests rises precipitously from the plains, and is formed of what may be called a "composite" dyke of greenstone. The dyke has an average bearing of 350 degrees, and is made up of four thin veins, each 3 feet in thickness, separated by about 10 feet of granite. To the southward these dykes coalesce and form a single vein. The rock weathers into characteristic, somewhat rounded, cubical blocks, presenting an appearance resembling courses of masonry. The vein can be followed across country for at least two miles.

Two miles distant from the hill, on a bearing of 224 degrees, is a very conspicuous knoll formed by the outcrop of a white vertical buck reef, which rises to a considerable elevation above the plain. The outcrop has an average strike of 22 deg. The ridge itself is about 10 chains in width, and is formed of a series of quartz reefs. There are two main reefs, A and B, about 10 chains apart, with several minor connecting veins. What may be called the main reef varies from 20 to 30 feet in thickness. A small, though conspicuous, hill of quartz occurs about two miles to the north, and, judging by the fragments lying on the surface, the reef thereon probably marks the continuation of the main reef described above.



From the well, last mentioned, the country as far as Lalla Rookh, at the foot of the range, is formed of granite of the usual type, and is traversed by greenstone dykes and several prominent quartz reefs.

The main road from Robinson's Hotel to Poondana traverses nothing but heavy, sandy plains, resulting from the disintegration of the granitic rocks beneath. The wells sunk for the convenience of travellers at Carlindie, the Strelley, and at Tabbab Tabba (Peterson's) all derive their supplies from the zone of decomposition of the granite, which latter was met with in every case.

Lalla Rookh lies at what may be called the southern margin of the great coastal plain, which presents many of the features which characterise a plain of marine denudation. Lalla Rookh forms a small but important mining centre, which has been responsible for the production of 7602 ounces of gold during the short period of its existence. Full details as to the mines of Lalla Rookh are to be found on a later page in Part II. of this report.

In this neighbourhood the first marked important change in the geological structure of the district occurs; here there is evidence of great earth movements and powerful rupturing of the crust, as represented by a line of dislocation, proved to extend for a distance of at least 50 miles. A generalised section across this fault, or rather series of faults, is shown on the Geological Map of Lalla Rookh.

The rocks exposed in the neighbourhood of the mining centre of Lalla Rookh consist of a series of greenstone schists and their allies, intrusive diabase (dolerite?), intrusive granite, laminated ferruginous jasper, together with a series of sedimentary rocks and associated lavas.

The schists occupy by far the largest area of country in the vicinity of the mines, and form the matrices of the most important of the auriferous reefs. The schists are vertical or nearly so, and seem to be arranged in a series of folds, the trend of which has been modified by the faulting which has taken place subsequent to the formation of the schists.

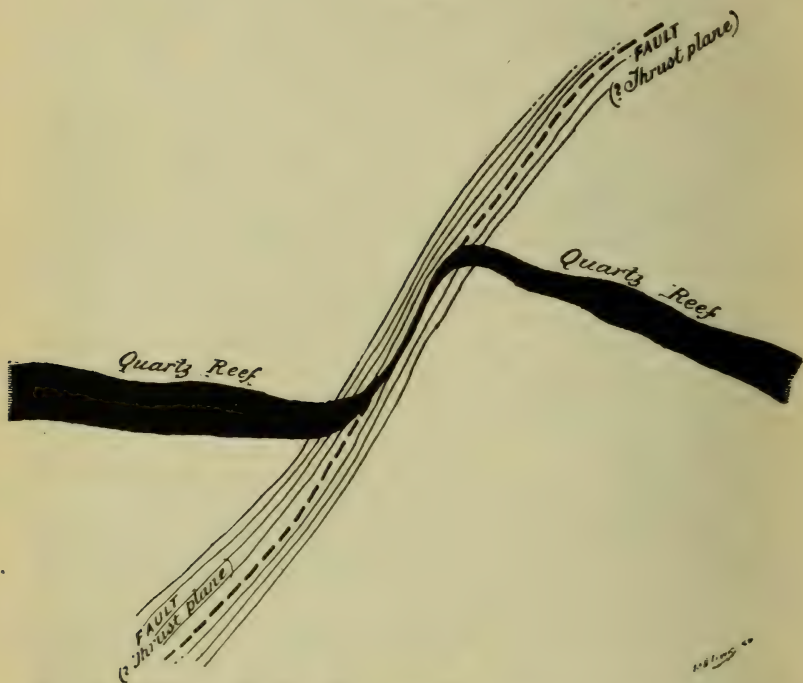
The quartz reefs have also been subject to the same faulting as the schists, in addition to having impressed on them structures brought about by what appears to be second foliation, which affected all rocks alike. At one spot near the face of the range, on the eastern bank of the Strelley River, an excellent section, showing the deflection of a quartz reef, is exposed, a plan of which forms Fig. 1.

This exposure occurs at but a short distance from what may be called the "main fault." The compression or shearing has been so great that this quartz reef, about 30 feet in thickness, has been reduced to from 6 to 10 inches, whilst the horizontal displacement has reached 150 feet. The quartz reef lies parallel to the lines of foliation of the schists in which it is enclosed, but a minor foliation can be detected by careful examination of country along either side of the attenuated portion of the reef.

This observation seems to indicate the occurrence of a double

foliation in the district; in another portion of the Pilbara Goldfield a somewhat similar condition of affairs has been noted. In the bed of the Big Sherlock River, where it is crossed by the road from Roebourne to Mallina, distinct traces of a double foliation in the gneiss has been recorded.<sup>1</sup> The older and coarse banding has a north and south strike at the Big Sherlock section, and at right angles to this are a series of secondary and much finer foliations,

FIG. 1.



PLAN SHEWING THE DEFLECTION OF A QUARTZ REEF STRELLEY RIVER PILBARA G.F.

within which it has the character of a mylonite or a fine quartz schist, perfectly distinct from the original rock.

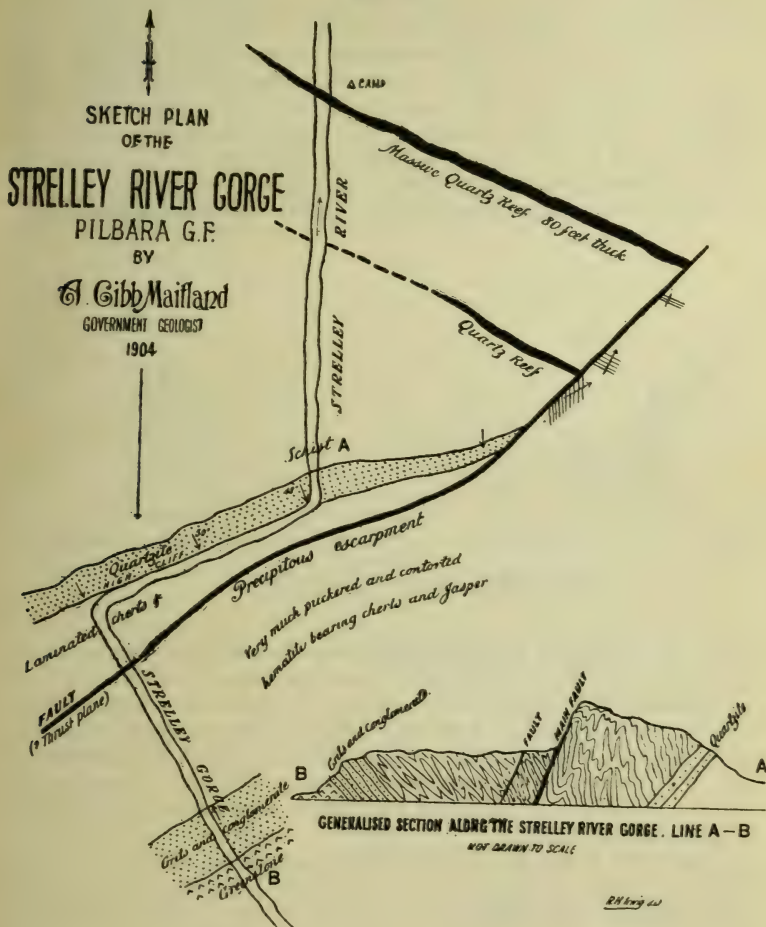
A good section of the fault and the quartzite beds on either side of the mass of plicated and laminated hematite quartzite may be seen in the Strelley Gorge; the section is about 2000 yards in length, and the high cliffs afford excellent opportunities for investigating the strata.

The sketch plan and sections forming Figs. 2 and 3 show the relations of the different strata very clearly.

<sup>1</sup> "The Geological Features of the Coast of Western Australia" (H. M. Cadell), *Trans. Geol. Soc., Edin.*, 1896.

At the camp on the Strelley River, a vertical quartz reef, 80 feet in thickness, formed a gorge through which the river flowed, and presented a huge wall which could be traced across country on a bearing of south 65 degrees east. At one point this reef was

FIG. 2.

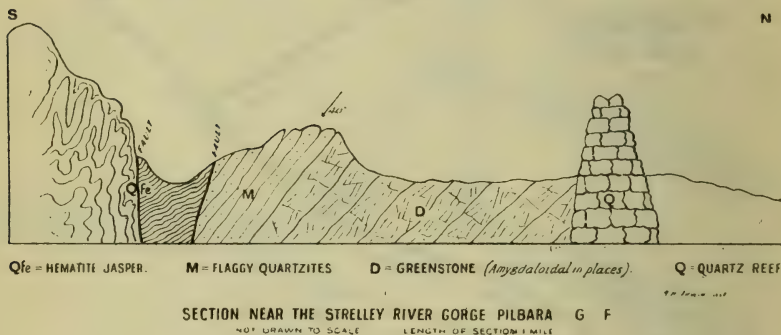


abruptly truncated by the main fault. To the south of this reef is another much smaller parallel, though equally conspicuous, quartz reef, also abruptly cut off at the fault, which has an average strike of north 65 degrees east.

About 700 yards above the camp the Strelley River cuts through a bed of grit and quasi-vitreous sandstone, dipping to the

south-eastward at an angle of 40 degrees, after crossing which the course of the river is deflected almost at right angles. From this point the river follows the high cliff formed by the escarpment of the sandstone bed for about 1000 yards, when its course is again deflected in a direction almost parallel to its original course. At this angle the river enters and eats its way through a gorge of about 1000 yards in length and a height of 300 feet, formed of very much puckered and contorted hematite-bearing cherts or jaspers. The southern end of the gorge exposes a section of grits [5380] and conglomerates for a length of about 220 yards, when their place is taken by diabase (?). The relation of the diabase (?) to the sedimentary beds is by no means clear; the occurrence, however, of amygdaloidal bands in one portion would seem to imply that it forms subaerial lava flow or flows. The diabase (?) appears to rise, as may be seen in the section, from beneath the sedimentary rocks,

FIG. 3.



but it is more than probable that there has been an inversion of the strata, and the grits, &c., fold over the face of the lava.

Although the Strelley River section does not throw any definite light as to the relations of the unfoliated igneous rocks to the sedimentary beds, other sections—Talga Talga, Bamboo, Yandicoogina, and the Nullagine River—prove conclusively that a series of volcanic rocks are interbedded with them, and occur not far from the base of the series.

Following along the face of the range, along the line of the fault as far as Trig. Station B 27, 980 feet above sea-level, magnificent sections are displayed in several places. The greenstone schists impinge directly against the fault in the vicinity of Lalla Rookh, but at a spot about a mile and a half west of B 27, the granite which penetrates the schists abuts against the plicated hematite jaspers, and follows the line of the fracture for some distance. The junction between the two formations is a faulted one.

A traverse of the Shaw River, from my camp at B 27 to a point about 14 miles above the North Pole Diggings, showed that the



country on either bank of the river is occupied for about 10 miles with those quartzites and conglomerates which occur in such great force to the south of Lalla Rookh. Numerous sections on the banks demonstrate the very much folded and faulted nature of the strata. From the summit of B 27 a bold vertical quartz reef trends generally southerly, forming an important reach of the river, and occurs along a line of fault. About 200 chains down the river from the site of the old Tremaine Mill, a section exposes the quartzite beds, abutting against the vertical schists, along a line of fault which trends generally north-east and south-west. A little distance to the south of the workings at North Pole a small patch of intrusive granite makes its appearance, but the exigencies of the work did not admit of its horizontal extent being made out. A long reach of the river, south-west from the old battery site, flows for a considerable distance over amygdaloidal lavas, which may form, as elsewhere in the district, the basal members of the Nullagine Beds. At a point about 10 miles from the battery site these give place to greenstone schists, which occupy a width, as measured at right angles to the strike, of about 300 chains. A bold, well-marked, laminated chert, trending generally east and west, and dipping south at an angle of 50 degrees, occurs in them; farther up the river these schists give place to quartzites, grits, and fine conglomerates, dipping at high angles to the south. The conglomerates contain pebbles and boulders of the cherts. The sedimentary beds are overlain in what appears, *primâ facie*, to be conformable succession, by a series of amygdaloidal lavas [5384] showing flow structure. An analysis of a typical specimen of one of these is that shown in the table on page 7; they resemble devitrified rhyolitic lavas. These volcanic rocks are faulted against the schists. A conspicuous hill of schist is traversed by a band of laminated and brecciated chert, which is steeply inclined to the west, and has an average strike of 200 degrees. This hill makes a very conspicuous feature in the landscape, and forms practically the southern extremity of the range; for, as far as the eye can see to the southwards, the country is practically an open plain, which may be underlain by granitic and gneissic rocks. This point is about 20 miles west of Marble Bar.

From our camp on the Shaw River, in the vicinity of this locality, a traverse was made to a very remarkable chert ridge, bearing 39 degrees from camp. The ridge, which has a strike of 269 degrees, forms one of the most conspicuous features in the district; and, rising to a height of about 650 feet above the river, affords an excellent view of the surrounding country. Between the camp and the foot of the ridge the country is underlain by vesicular lava. The thickness of the chert, as measured at one spot near the summit, is about 100 feet; the central portion is very brecciated, and the fragments are recemented by secondary silica. As measured near a gap on the summit of the ridge, which is of considerable extent, the dip of the chert is 50 degrees to the south.



With the object of gaining a little knowledge of the sedimentary rocks, on the return journey to the Shaw River crossing at B 27, a detour was made to a high round-backed mountain, which reared its summit to 960 feet above the river, and from its shape I have named it Mount Hogback. The traverse, however, afforded little fresh information except that the hill consisted of grit, quartzite, conglomerate, fine sandstone [5388] and a thin bed of drab-coloured shale, faulted against the schists. Mount Hogback lies a little to the south-west of the North Pole Battery, and about 300 chains distant. The traverse up the Shaw River demonstrates that there are two distinct belts of the Nullagine Beds, separated by about 500 chains of schists and allied rocks, and in both cases the junction is marked by a vertical fault.

### B.—The Country between the Shaw and the Coongan Rivers

The main road from the Shaw River to Doolena Gorge on the Coongan follows closely the foot of the main range and affords many opportunities for the structure of the country being carefully examined. Cooke's Bluff Hill, on Miralga Creek (Little Shaw), is of the same formation as B 27, and has a bold quartz reef on the southern face. From this point to a creek about 8 miles from the Shaw, granite and gneiss is the staple formation.

Near what is shown as Gorge Creek Well, on the Lithograph 15 G, issued by the Department of Lands, the granite gives place to a belt of schists, which occupy a fairly extensive stretch of country in the vicinity. The general strike of the outcrop of the schists is north and south, and the beds are vertical. There are a series of jasper or chert bands associated with the schists in addition to dykes and masses of unfoliated igneous rocks.

This patch of schists is said to have yielded promising prospects of gold. Considering the identity, in the geological features, of this area with that of Lalla Rookh, it would indeed be surprising were gold not found in the vicinity.

The main range to the south, which is breached by Gorge Creek, shows the following section:—

FIG. 4.



Between Gorge Creek and the Coongan River, the country in the vicinity of the main road is occupied by granite or gneiss, traversed by greenstone (diabase?) dykes, which stand out in bold

relief, with black weathered summits. These dykes, which form a very marked feature in this portion of the district, were evidently formed later than the general foliation of the district, and later than the powerful rupturing which the country has undergone.

The country in the vicinity of the Coongan River, near its junction with Duffer's Creek (*vide* Lands Office Lithograph G 16), shows the staple formation to be basic rocks, into which felsite dykes [5392] have intruded. An analysis of one of these is shown in the table on page 7.

A traverse to the high range due west of the mouth of the creek showed that the flats were underlaid by volcanic rocks, many beds of which are formed of agglomerate. These volcanic rocks, which are continuous with those of the neighbourhood of Talga Talga, give place to a vertical bed of jasper [3593], which rises to a considerable height above the general level of the surrounding country. The jasper contains crystals of magnetite. The general strike of the ridge is 189 degrees, and in all probability forms the continuation of the "Marble Bar," which crosses the Coongan about a couple of miles from the township. As viewed from the summit of the ridge, the country to the westward appeared to be made up of what appear to be practically horizontally bedded rocks, which in all probability represent the quartzites and conglomerates which occupy the country in the vicinity of Lalla Rookh and the Shaw River, near B 27.

### C.—The Country between the Coongan and the De Grey (Nullagine) Rivers

Travelling from the Coongan River, where it is crossed by the main road at Doolena, towards Talga Talga, the country is found to be underlaid by a series of almost vertical schists, which have an average strike of north-east and south-west; the schists contain bands of ferruginous jasper of the type prevailing in other portions of the district. About a couple of miles east of Talga Talga the schists give place to granite, which occupies a considerable area of country, extending as far northward as Marble Bar, and includes within its boundaries the tin-bearing area of Moolyella. Sections in the vicinity show that the granite is intrusive, for it is seen to have insinuated itself into the schists in the form of veins, dykes, and bosses. The granite is composed of quartz, felspar, and mica, and is traversed by many north and south quartz reefs, and a series of pegmatite veins, which, when laid down upon a map, exhibit a general parallelism, and which, when viewed on the whole, conform to the strike of the quartz reefs.

The stresses and strains consequent upon the intrusion of the granite mass has resulted in the production of a series of joints, &c., which has formed the channels, up which mineral-bearing solutions have percolated, and deposited in the one place free quartz, forming the persistent reefs, and in the other

have attacked the constituents of the granite. The result of this latter action is a rock [5397] made up principally of quartz, albite, a little mica, together with a few garnets and cassiterite. Considering the very large area, about 900 square miles, over which the granite has been proved to exist, with a remarkable uniformity in its structure and composition, it is by no means improbable but that careful search would result in the discovery of other portions of it quite as rich in tin as that at Moolyella.

From Moolyella to Talga Talga Soak, which lies some miles to the north-east, the whole of the country is occupied by granite of what may, for convenience, be called the tin-bearing type. At the Soak, merely a sand-well in the creek, numerous pegmatite veins occur; these are worth careful prospecting for tin ore.

From Talga Talga Soak and bearing 260 degrees is what is called the Twin Sisters, a conspicuous ridge which forms a very prominent feature in the landscape visible for many miles around. Granite occupies the country from the Soak to the ridge, which presents a high vertical face to the east. The ridge is composed of a vertical quartz reef, from 20 to 30 feet in thickness, having an average strike of 185 degrees, agreeing very nearly in this respect with that of the quartz reefs at Moolyella. The ridge derives its name from the circumstance that it is breached by a creek, cutting the reef almost into two halves. From Talga Talga Soak to the 5-Mile Well on Reserve 8288, about 4 or 5 miles west of Bamboo Township (*vide* Mines Litho. L. 80 and Lands Litho. 15 G) is occupied by granite. This well occurs just at the western margin of a series of greenstone schists and their allies, which have been traversed by several persistent belts of laminated quartzites (? cherts) some of which attain a great thickness (one measuring 1200 feet across) and rise to considerable altitudes above the level of the surrounding country. Associated with these schists are small areas of unfoliated greenstones (diabases). Somewhat fuller details connected with these rocks are given in the second half of the report dealing with Economic Geology.

In the neighbourhood of Bamboo a series of sedimentary rocks, quartzites, grits, conglomerates and shales, together with a series of interbedded volcanic rocks, occur (Nullagine Beds). These strata, which form the north-eastern boundary of the auriferous series of Bamboo, occupy a considerable area of country, and are continuous as far as Yandicoogina on the south. So far as has been observed, the granite does not penetrate the sedimentary beds and their volcanic associates. The sedimentary rocks are bounded on the west by a powerful fault, a section of which is shown on the Geological Map of Bamboo.

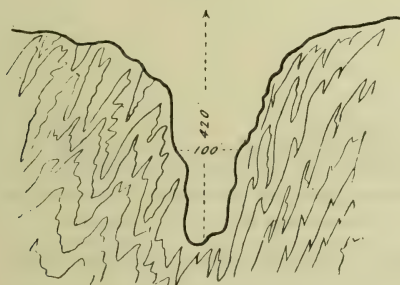
While at Bamboo, opportunity was taken to examine the country to the north-west, and to this end a traverse was made to a gap (Coppins?) in the Jasper Range, some miles distant from the camp (Reserve 8288). The route followed the junction of the granite and schists and their alteration products. The gap (Fig. 5)



has been carved out of a bed of laminated jasper, which, as measured in the gorge, attained a thickness of 1200 feet, and a height of 420 feet vertically above the level of the creek. The gorge is only 100 feet across from wall to wall in its widest part.

The section exposed shows that the jasper (chert?) has been violently plicated, and in certain parts faulted, the lines of fault being often filled with a fault-breccia of jasper, recemented by secondary silica. The ridge is a continuation of that at Eginbar and Doolena,<sup>1</sup> and is continuous as far as Bamboo, when it disappears by faulting beneath the sedimentary rocks. An excellent view of the country to the north can be obtained from the summit of the ridge, the Black Range,<sup>1</sup> upon which Trig. Station B 24 is situated, stands out very prominently and bears 298 degrees. The Black Range is formed of a greenstone dyke, which stands out boldly on the back of the ridge, and the series of dark, almost

FIG. 5.



SECTION ACROSS COPPINS GAP N. BAMBOO CREEK PILBARA G.F.

black, weathered rocks give the name to the Range. The dyke extends for many miles to the north-east.

The country due north in the direction of the De Grey River is seen to be covered with numerous flat-topped hills, made up of those bedded rocks which form such a pronounced feature in the vicinity of Bamboo Creek, of which no doubt these beds are a continuation. To the north-west the country appears to be practically a level plain underlaid by crystalline rocks of what may be called the Lalla Rookh-Port Hedland type, described on previous pages.

The track from Bamboo to Yandicoogina crosses the auriferous series of Bamboo to the south of the Bulletin Mine, and occupies the country to a point about 4 miles north of Lyons' Well, when its place is taken by granite of the usual type. A point about 2 miles east of the well marks the boundary of the granite in this direction. From Lyons' Well to Jones' Well, about 24 miles, granite rocks prevail; these are penetrated by a few greenstone dykes. So far as may be judged by a distant view of

<sup>1</sup> Vide Lands Department Lithograph, G 16. Perth: By Authority, 1902.

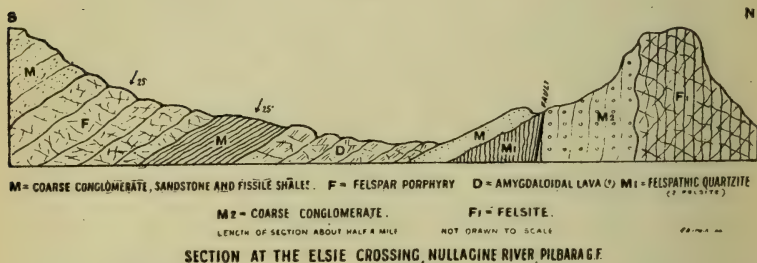


the most conspicuous summit in the neighbourhood, Mt. Edgar, it appears as though the mountain were formed of greenstone also, possibly in the form of a boss. Some miles to the east of the track the escarpment of the Nullagine Beds could be described, forming a kylie (boomerang) shaped continuous outcrop of what appear to be horizontally bedded rocks. The granitic rocks occupy the country to within a very short distance of the mining centre of Yandicoogina, when their place is taken by schists, which with one exception form, as elsewhere in Pilbara, the auriferous series.

As may be seen by an inspection of the geological sketch map of Yandicoogina, the junction between the Nullagine Beds and the schists is marked by a fault, the general trend of which is north-east and south-west.

One section in the vicinity of Yandicoogina shows beneath the grits and quartzites of the Nullagine Beds, a series of vesicular lavas. The base of this formation being concealed by a fault with

FIG. 6.



a downthrow to the west, cannot be seen, hence no estimate can be formed of the total thickness of the volcanic rocks.

From Yandicoogina to the De Grey (Nullagine) River, at what is called the Elsie Crossing, the road trends generally south-east, following the southern escarpment of the sedimentary rocks. From beneath the sedimentary beds emerge vesicular, amygdaloidal lavas. The base of these was not noticed in any of the sections exposed within easy reach of the main road.

An instructive section is exposed in the vicinity of the crossing, and is shown in Fig. 6.

From this section it appears that there are two distinct series of sedimentary rocks, an upper, the Nullagine Beds, resting upon the upturned edges of a series of quartzites, coarse conglomerates, and felsitic lavas.

Some miles below the crossing, an island in the bed of the De Grey (Nullagine) River, shows a small thickness of sedimentary rocks, sandstones and coarse conglomerates, containing boulders of vesicular lava and felspar porphyry. The relations of this newer series to the surrounding rocks are not quite clear.

### D.—The Country between the De Grey (Nullagine) and the Oakover River

At a point about 4 miles east of the Elsie Crossing, granitic rocks make their appearance from beneath the volcanic beds and occupy the surface for about 6 miles. To Mount Elsie the road is unusually rough and rugged, winding in and out as it does among the numerous gullies between the hills, and is carried over volcanic rocks and their derivatives.

The reefing centre of Elsie lies at the foot of an extremely rugged mountain from which the district takes its name and which can be seen for several miles in all possible directions.

The sections seen at intervals along the track between De Grey (Nullagine) and the Elsie seems to show that what may be called the pseudoschistose rocks are merely a dynamically altered form of volcanic rocks; it is however not clearly proven that this is the case, but if more minute investigations should demonstrate that these schists are merely transmuted volcanic rocks, an important light is thrown upon the geological features of the more southerly goldfields. Whether these igneous rocks are contemporaneous with those lying at or near the base of the Nullagine Beds remains to be proved; the impression left on the mind is that they (the schists) are of much older date. Mount Elsie is formed of schists intersected by numerous laminated iron-stained quartz reefs, with thin quartz leaders ramifying in all directions. These schists are sandwiched as it were in between two belts of limestonelike weathering schist of the type common to certain portions of the auriferous series of the north-western goldfields so far examined. A conspicuous bluff about 4 miles nearly due east of Mount Elsie, at the foot of which lies Duncan and Sullivan's gold mine, shown on the existing lithographs issued by the Government, shows a section of a decomposed felsitic lava resting upon a series of conglomerates and sandstones dipping at about 5 degrees to the south-west.

The coarse conglomerate which forms the base of the Nullagine Beds in this locality, reposes directly upon the upturned edges of the schists, and contains pebbles of granite and schist. The basal conglomerate attains a thickness of from 10 to 12 feet. The decomposed felspathic lava rises to a height of about 300 feet above its base. The summit of the bluff shows a thin bed of very fine grained chocolate-coloured sandstone, about 4 feet in thickness.

The schists beneath the Nullagine Beds in this locality are seen to be pierced by veins and dykes of granite.

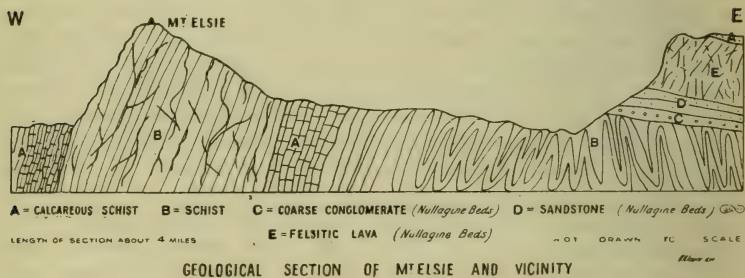
Fig. 7 is a generalised section from the summit of Mount Elsie to the eastward.

The country to the east of Mount Elsie consists of a succession of low greenstone ridges. The greenstones are in many places somewhat markedly schistose and are intersected by parallel bands

of laminated cherts. Associated with the schists are also patches which weather with a limestonelike character. The highest hill in the neighbourhood rises to a height of 400 feet above the surrounding country, and appears to be made up of a massive unfoliated greenstone (diabase?). One portion of it is covered with a thin bed of decomposed quartz felsite. To the south-west of this hill, the sandstones and conglomerates of the Nullagine Beds make their appearance, abutting against the greenstone by a fault. At the junction, the sandstones have a dip of 47 degrees to the west, which at some distance from the fault has flattened to 25 degrees. The sandstones are covered by a dolerite (diabasic) lava, upon which rests a bed of limestone [5419] about 15 feet thick. The limestone is covered by amygdaloidal diabase. The limestone is apparently unfossiliferous, and dips west at 20 degrees. The bed can be traced along its strike 52 degrees, for a distance of about one-and-a-half miles.

From Mount Elsie to Martin's at Boodalyerri, the country after leaving the schists is occupied by granite of the normal type.

FIG. 7.



From Martin's to the Oakover, the bridle track is carried over granitic rocks for about 14 or 15 miles. The whole country is traversed by several very prominent quartz reefs, which are approximately parallel to one another. Several of these have been prospected with fair results. Considering the number of prominent reefs outcropping in the vicinity, and the rich chutes known to occur in the few that have been prospected, there is every encouragement for the prosecution of further prospecting.

Leaving what is known as the Reward Claim, a traverse was made down Boodalyerri Creek, as far as its junction with the Oakover.

Leaving the granite country about 120 chains below the head of the creek, down which the bridle track follows, a great series of what appear to be almost horizontally bedded fine-grained volcanic rocks make their appearance, and occupy the surface down to a point about 4 miles due west of Carawine Pool on the Oakover River.

Near the head of the creek a thin bed of limestone 4 to 5 feet thick, is interbedded with the volcanic rocks. The limestone,



which dips at a low angle to the south 50 degrees west, rests upon amygdaloidal diabase (?), and is covered by a dense fine-grained greenstone.

Boodalyerri Creek from this point flows over a succession of amygdaloidal lava beds, to a point on the creek about 5 miles above its junction with the Oakover. Emerging from the constricted portions of the valley, the outcrop of the volcanic series can be followed for some miles to the north, and is in all probability continuous with that which forms the Ripon Hills, to the west of Gregory's 68th camp on the De Grey (Nullagine). In the year 1898, there being no officer of the Geological Survey staff available, Professor (then Mr.) R. Neil Smith, was specially employed, and during his work in this district, inquiring into the possible occurrence of artesian water between the Pilbara Goldfields and the Great Desert, gave some further particulars as to these trappean rocks. In his report this observer states:—

Some 4 miles east of the Oakover River, and running approximately parallel with it, a prominent range rises abruptly from the surrounding alluvial plains. This consists, where inspected, of an amygdaloidal melaphyre, the exact nature of which it was impossible to determine, owing to the decomposition of the exposed rock. This range is from 200 feet to 400 feet above the bed of the river, and extends for a distance of many miles, skirting the greater portion of the eastern boundary of Warrawagine.<sup>1</sup>

The position of this volcanic rock is shown upon the geological sketch map which accompanies Professor Neil Smith's report. My own personal acquaintance with the country to the west of the Oakover, leaves but little doubt but that this is merely the eastern extension of the volcanic rocks traversed by Boodalyerri Creek.

At Carawine Pool, on the western bank of the Oakover River, an excellent section is seen of the limestone [5420] of the Nullagine Series. A section of this is shown in Fig. 8. The limestone [5420] is of the same lithological character as that exposed in Boodalyerri Creek, and also in the country to the west of Mount Elsie, referred to on a previous page. The thickness of the limestone in the Carawine Pool section is, as measured, not less than 300 feet. The base of the limestone is exposed on the eastern side of the Pool, on a small washaway, and seen to rest upon the beds of the volcanic series. The limestone contains bands of chert [5421] and jasper. The limestone is capped by about from 20 to 30 feet of siliceous breccia, which rests upon an uneven floor of limestone. The breccia is crowded with angular fragments of quartz and chert. This bed possibly forms the north-western extension of a mass of siliceous breccia, 300 feet in thickness, which outcrops at about 2 miles distant on the bank of the Oakover River.

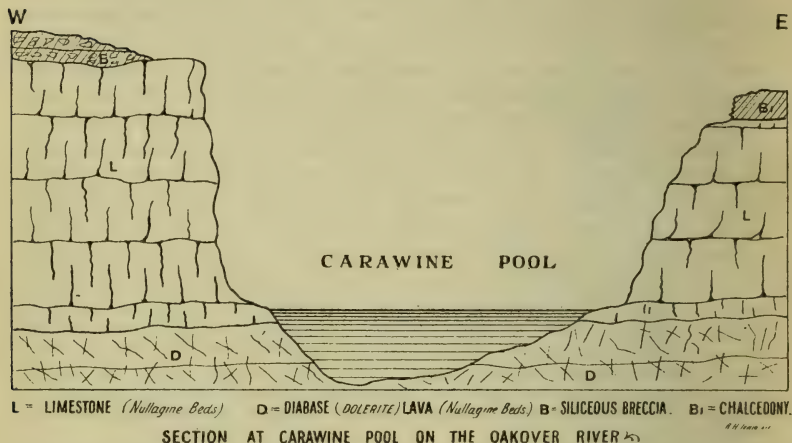
The limestone forming the Nullagine Series, as exposed at Carawine, evidently covers a fairly wide extent of country, for

<sup>1</sup> The Probability of obtaining Artesian Water between the Pilbara Goldfields and the Great Desert. R. Neil Smith, Geological Survey Bulletin No. 2. Perth: By Authority 1898, p. 25.



Prof. Neil Smith, in his report previously quoted, also notes its occurrence at Tooncoonarlagee, at a point about 14 miles to the southward. This observer states that springs of water, highly charged with carbonate of lime, issue from the base of the lime-

FIG. 8.

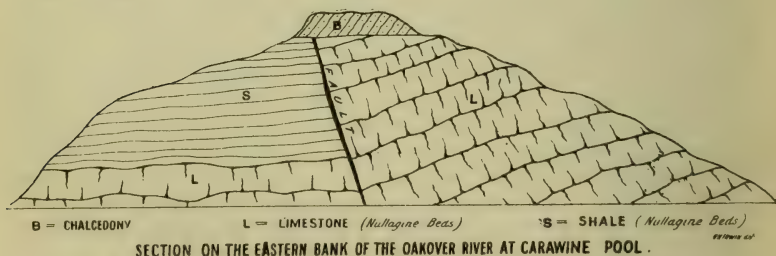


stone cliffs and flow into the Oakover at a rate of many thousands of gallons per day.

On the eastern bank of the Oakover, at Carawine Pool, the section depicted in Fig. 9 is exposed.

The summit of the hill is formed of a small tableland of chalcodony [5423] and a white limestone [5422], the whole forming a

FIG. 9.



thickness of about 20 feet. These rocks (the Oakover Beds) rest with a violent unconformability upon a dull greyish brown limestone and calcareous shale. The older limestones were folded and faulted, prior to the formation of the chalcodony capping. No fossils were detected in the limestones of either series. The base of the lower limestone series is not seen anywhere in this section.

The upper limestone series (Oakover Beds) evidently covered a wide extent of country, for outlying mesas of it are found extending for 5 or 6 miles up Boodalyerri Creek, resting upon the volcanic beds, whilst several outliers can be seen in the country to the northwards. These isolated mesas form impressive evidence of the amount of denudation which has gone on since the formation was laid down. Describing this formation, Prof. Neil Smith, in his report previously alluded to, states :—

Five miles south of the homestead (Warrawagine Station) a low, irregular series of limestone hills make their appearance. These hills are all of small extent, and are dotted in all directions over the strip of country between the Nullagine and Oakover Rivers. The summit of nearly every hill is, to the eye, perfectly horizontal, due to horizontal beds of limestone from denudation. The flats between these hills consist of limestone, with here and there small stretches of bow-shaped ironstone pebbles. This belt of limestone country is bounded on the east by the Oakover River, crossing it only for a very limited area 10 miles south of Braeside Station.

It is quite clear from Prof. Neil Smith's descriptions and his geological map that he did not recognise the violent unconformability between the Oakover and the Nullagine Beds.

Returning from Carawine to Mount Elsie, a traverse was made from that centre to Mosquito Creek. Two miles from Elsie the bedded volcanic rocks make their appearance and occupy the country for about 10 miles, at which point schistose rocks of the usual type emerge from beneath them and occupy the country as far as the Mosquito Diggings.

The schists in the vicinity of Mosquito are associated with a series of grits, shales, and fine conglomerates, from which, however, they could not, in the few hasty traverses I made, be satisfactorily separated, as no obvious and well-marked stratigraphical break could be detected. These beds have been invaded by granitic rocks [5425]. The schists and allied rocks continue without interruption as far as Nullagine, where they again pass beneath the strata forming the Nullagine Series.

The road from Nullagine to Marble Bar, as far as Dewhurst's Well,<sup>1</sup> traverses the eastern slopes of the escarpment of the sedimentary rocks of the Nullagine Series. The well, so far as may be judged by the débris round the mouth, has been sunk in sandy shale, or at any rate in fine-grained sandstone. Some little distance to the north of Dewhurst's Well, the road surmounts a bed or "sill" of porphyritic lava, not unlike that occurring at Bamboo Creek. This bed occupies the country as far as Trigonometrical Survey Station G 21, when the road descends to the sedimentary beds beneath. At Hale's Grave Well to Carvana Well the road follows the beds of the Nullagine Series, which gives place to granite of the normal type; this occupies the country as far as Corunna Downs Station, and to a point about 6 miles northwards, when schistose rocks prevail.

<sup>1</sup> Lands Department Lithograph, 16 G.

## PART II.—ECONOMIC GEOLOGY

### SECTION I.—GENERAL

THE Pilbara Goldfield contains several gold- and tin-bearing areas, scattered over different portions of the district. Economically, the auriferous deposits have proved, up to the present, to be the most important.

The geographical position of the various mining centres, so far examined, suggests a zonal development of the auriferous deposits. So far as observations have yet been carried, it appears that the auriferous deposits of the district may be divided into four main and distinct groups, viz.: (a) Lalla Rookh; (b) Talga Talga, Bamboo; (c) Marble Bar, Yandicoogina, Mount Elsie; and (d) Mosquito, Middle Creek, Nullagine.

The length of the Lalla Rookh belt has not yet been defined, but it does not appear to be less than 30 or 40 miles; the Talga Talga-Bamboo belt, which probably includes the North Pole Diggings, is 50 miles in length; the Marble Bar-Yandicoogina belt, of which Mount Elsie is probably the continuation, has a proved extent of about 60 miles; whilst the Nullagine-Mosquito zone is known to extend for a distance of at least 40 miles. There are strong geological grounds for the belief that this latter belt continues much farther to the east, and may possibly cross the upper reaches of the Oakover River.

The general direction of these belts almost everywhere coincides with the strike of the greenstone schists, which, with two exceptions, invariably form the matrices of the auriferous reefs. The prevailing direction of the auriferous deposits, when viewed broadly, is east and west (sometimes changing to north-east and south-west), and north-west and south-east.

The width of the belt naturally varies, and in the three most northerly zones the exact width cannot be defined, owing to the fact that one of the boundaries is invariably marked by a powerful fault, which throws down the beds of the Nullagine Series against the schists and their allies.

The prevailing dip of the auriferous belts coincides with that of the enclosing schists, which is generally to the southward.

Quartz reefs occur in great abundance all through the schistose rocks, as well as to a more limited extent in the areas occupied by the granite rocks. The quartz reefs are of two distinct types, viz., white quartz reefs, and laminated quartz and jasper veins, approaching very closely the hematite-bearing quartzites (?) which invariably form a conspicuous feature in most of the goldfields of the State which have yet been examined. It is quite possible that the laminated quartz reefs are either merely silicified schists or reefs of an



earlier formation which have undergone the same compression and shearing which induced the foliation of the schists. If the latter, then it is quite clear that what may be called the massive reefs are of later formation than the laminated reefs. In many cases the laminated quartz reefs are traversed by quartz veins of a later date. Some of the laminated quartz veins (quartzites) range from almost pure quartz, through banded jaspers, with crystals of magnetite, to bands appearing to the eye to be virtually pure hematite. Some of these—notably those in the Lalla Rookh zone—could be readily concentrated to high-grade ores. At present these deposits are beyond the reach of commercial enterprise, but under more favourable conditions there is little doubt but that some of them might be turned to profitable account as sources of iron ore. The quartz reefs of what may be called the massive type occur plentifully in both the schist and the granite areas, though it is only in the former that the laminated and iron-bearing quartz veins have been found, conforming in this respect to their mode of occurrence in the Southern Goldfields. The reefs invariably occur along the planes of foliation (? bedding) of the schists, or at any rate cut them at a very low angle. In some cases the reefs present characteristics which seem to indicate that they have been torn apart by movement along shear planes.

The auriferous reefs cannot be said to be long, and are as a rule small, though they occasionally swell out into large lenticular masses. Some of the reefs have been traced along the outcrop for over 2000 feet, and have swelled out to masses measuring about 15 feet across.

The value of any reef being in a large measure influenced by its richness and its quantity—by which latter is meant the thickness, length, and breadth of the shoots of gold—wherever possible, observations were made tending to throw light thereon. In no case, however, had the workings been carried sufficiently deep to enable any very reliable data being obtained as to the exact mode of occurrence of the ore shoots. In one case—the Zephyr Lease, at Talga Talga—observations were made which seemed to show that the rich ore shoots invariably occurred in the vicinity of a series of vertical fractures, traversing the reef, on a bearing of south 30–40 west. So far as may be judged from the official returns from the various properties, it appears that the shoots of gold are rich; but when the shoots got relatively poor operations ceased, for, owing to the economic conditions prevailing, only the richest ores could be worked at a profit.

The auriferous ores are, with one exception, all of such a character as render them readily amenable to battery amalgamation and cyanidation; whilst the tin ores so far examined seem to be free from those deleterious constituents which are known to occur associated with the ores of the Greenbushes Tinfield.

The following table shows the value of the mineral production



of the different portions of the Pilbara Field visited and reported on up to the end of the year 1903 :—

Mining Centre.	Gold.			Tin.	
	Ore Crushed.	Gold therefrom.	Rate per Ton.	Ore Raised.	Value.
	Tons.	Ozs.	Ozs.	Tons.	£.
Bamboo Creek . . .	10,698·25	20,444·35	1·91	855·58	56·163
Boodalyerri . . .	106·25	1,037·05	9·76		
Elsie Creek . . .	428·25	1,431·72	3·34		
Lalla Rookh . . .	6,532·50	7,602·96	1·16		
Mosquito Creek . . .	3,053·94	5,305·35	1·73		
Moolyella . . .	...	...	...		
North Pole . . .	416·00	324·40	·78		
Sandy and Middle Creeks .	3,816·30	9,025·65	2·36		
Talga Talga . . .	891·65	2,012·28	2·25	855·58	56·163
Yandicoogina . . .	2,162·75	5,767·50	2·66		
Total . . .	28,105·89	52,951·26	1·88	855·58	56·163

While the above table gives fairly reliable data as to the production of the reefs, the amount of alluvial gold can only be roughly approximated. The large nuggets for which the district is famed are distinctly of local origin, and are derived from the disintegration of quartz veins. From the data given in the above table it appears that the average yield per ton of ore crushed from the district alluded to has been 1·88 ozs. per ton; it is, however, unlikely that the high average of the last few years will be maintained under existing conditions. There is, however, a fair extent of low-grade ore deposits not yet developed, which under more suitable conditions, might be turned to profitable account.

The tin deposits so far worked are all of detrital origin, and have yielded considerable quantities of tin ore. Lode tin is also known to occur at Moolyella, but owing to low percentage has not yet been worked. There is every encouragement to search for richer deposits over the 900 square miles which the tin-bearing granitic rocks have been proved to extend.

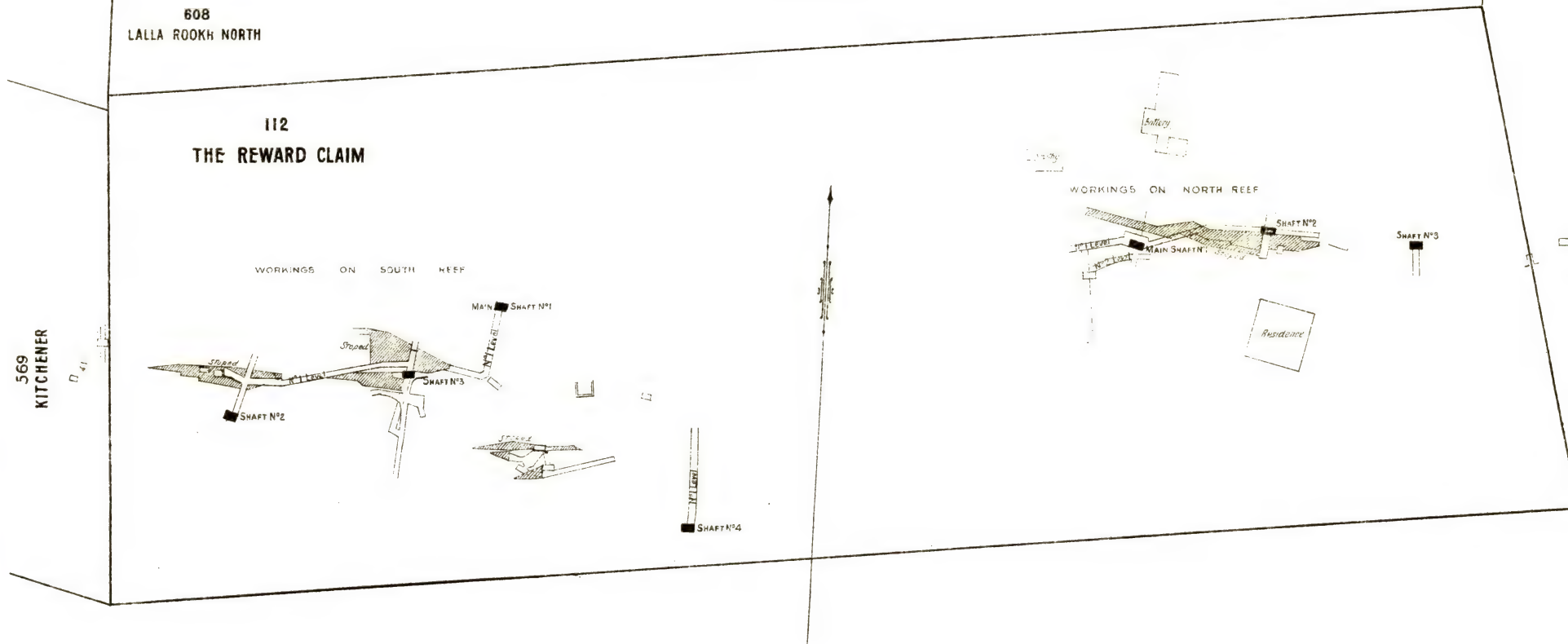
Detailed descriptions of each mining centre visited are given below, and to facilitate description are accompanied by a series of geological maps, in addition to tables of statistics, taken in every case from official sources.



# PLAN & SECTIONS OF THE LALLA ROOKH GOLD MINE

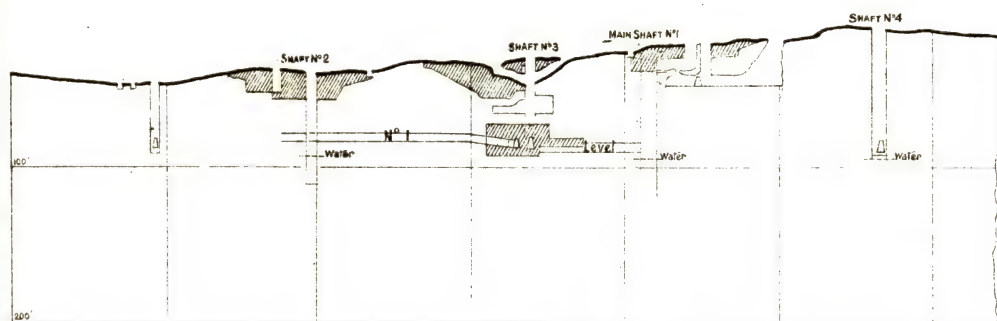
PILBARA C.F.  
Reduced from the Main Plans

Scale of feet

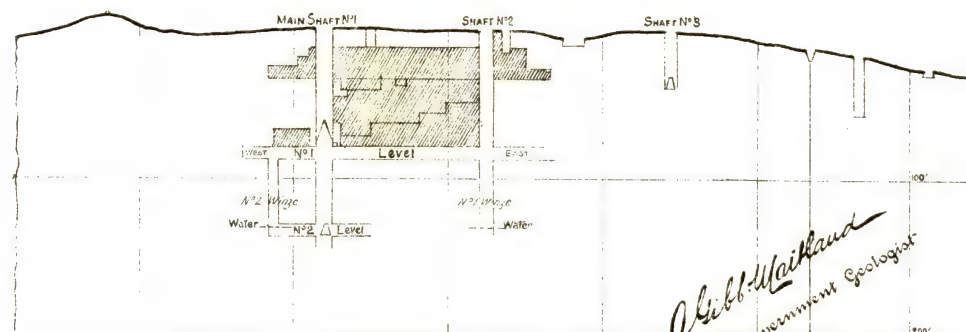


## LONGITUDINAL SECTIONS

SOUTH REEF



NORTH REEF



*Alfred Wainman*  
Government Geologist

31/7/03

R.M. Parnham del.

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THE SHAW COIN

PULCHER  
720



## SECTION II.—DESCRIPTION OF INDIVIDUAL MINING CENTRES

### A.—Lalla Rookh

*(With a Geological Sketch Map and Sections, Plate II.)*

The mining centre of Lalla Rookh is situated 45 miles west of Marble Bar (the official centre of the Pilbara Goldfield), about 4 miles west of the Trigonometrical Survey Station B 27, on the Shaw River; its position is shown on the locality plan which forms the frontispiece to this report.

The field was discovered, according to the Warden's report, in the year 1899, and since that date has yielded 7,602·96 ozs. of gold, the result of the crushing of 6,532·50 tons of quartz; the average yield per ton being 1·16 ozs.

A geological sketch map, to which is attached a generalised section across the field, designed to illustrate its structural features, accompanies this report. As by far the larger portion of the area was practically a blank upon any of the existing maps, operations had to be commenced by preparing a plan of the vicinity of the mines. In the preparation of this I am under obligations to the local representatives of the British Exploration Company, who courteously placed at my disposal the lease plans in their possession, and in other ways materially facilitated the work.

Lalla Rookh lies at the foot of what may be called the Main Range, which presents a steep face to the coastward, and extends north-east and south-west for considerable distances.

The rocks of the field consist of greenstone schists and allied rocks, diabase, granite, laminated ferruginous jasper, together with a series of quartzites, grits, and conglomerates, shown on the accompanying map. The alluvial deposits form a wide strip along the banks of Lalla Rookh Creek, but they nowhere attain any great thickness.

The greenstone schists, and allied rocks, occupy by far the largest area of country in the more immediate vicinity of the mines, and it is amongst these rocks that the most important auriferous reefs yet opened up occur. The schists are vertical, or are inclined at high angles, and appear to have been arranged in a series of folds, the trend of which has been materially modified by the faulting which has taken place, subsequent to their formation. The position which these beds occupy has been delineated upon the geological map with such a degree of accuracy as the scale of the field plans would admit.

Without much more detailed work than has been possible to carry out up to the present time, it is not possible to determine whether all the "greenstone" schists are of igneous origin, or merely represent ancient sedimentary beds which have been subjected to regional metamorphism.

The schists, and allied rocks, have been invaded by dykes of diabase, the positions of which have been shown on the map. A mass of intrusive granite occupies the western margin of the field, and forms part of that extensive area which occupies the greater portion of the country between Lalla Rookh and the coast at Port Hedland. This granite is clearly of older date than that of the quartzites and other associated sedimentary beds; in no case, however, does the granite rise to the level of and pierce them.

The south-western portion of the field is occupied by a narrow strip of very much contorted ferruginous jasper and chert, which, rising with a steep vertical escarpment often over 100 feet in height, makes a very conspicuous feature in the landscape, visible for many miles.

Against these jaspideous rocks abut a series of quartzites, grits, and fine conglomerates. Owing to the faulting, &c., which has gone on in the district it is difficult to be sure of the general direction of the strike over the limited area which it was possible to examine the sedimentary rocks. The conglomerates contain pebbles and fragments of the cherts and jaspers [5387]. These beds afford no direct evidence as to their geological age, and until much more information is available their exact position in the geological time scale must be an open question. The assumption is, however, that they represent the southward extension of the strata of the King Leopold Range, Kimberley, and which are inferentially referred to the Cambrian System.

A considerable amount of faulting has gone on in the district, as may be seen by an inspection of the geological map. The boundary separating the sedimentary rocks from the jaspers, &c., is a line of fault. No attempt has been made to locate all the faults and to trace them over the ground; hence only the most prominent have been shown; to have done more than this would have required much more accurate maps than were at my command, and would have necessitated much longer time being devoted to the work than was deemed called for at the time. The faulting appears to have had the effect of shifting the outcrop of one of the reefs—the Bergamina—the most pronounced, though not the most important, on the field.

The quartz of which the whole of the reefs at Lalla Rookh is composed is generally of a milk-white colour, and contains, with but one exception, very little pyrites.

### THE REEFS

The following is a description of such of the mines as were open to my inspection:—

BERGAMINA, G.M.L. 606.—This lease is the most northerly of any yet worked at Lalla Rookh. There are four distinct reefs on the property, but only upon two of them has any serious work been done. There are two shafts on the property. The most northerly





GEOLOGICAL SKETCH MAP

OF

**LALLA ROOKH**

PILBARA G. F.

BY **G. GIBB MAITLAND**

GOVERNMENT GEOLOGIST

AND

H. W. B. TALBOT

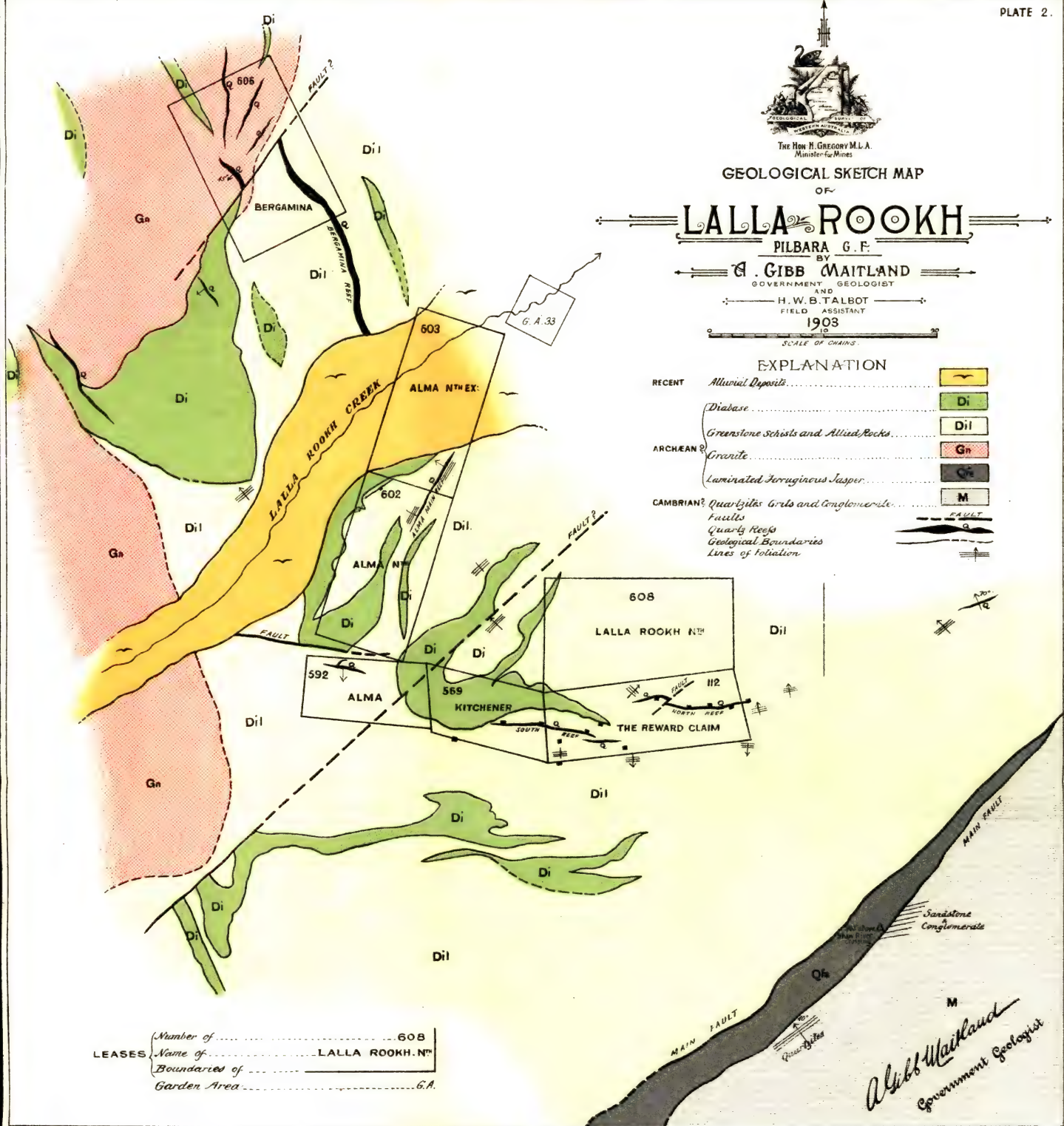
FIELD ASSISTANT

1903

SCALE OF CHAINS.

EXPLANATION

RECENT	Alluvial Deposits	
	Diabase	
	Greenstone Schists and Allied Rocks	
ARCHAEO	Granite	
	Laminated Ferruginous Jasper	
CAMBRIAN?	Quartzites, Grits and Conglomerates	
	Faults	
	Quartz Reefs	
	Geological Boundaries	
	Lines of foliation	



LEASES (Number of ..... 608  
Name of ..... LALLA ROOKH, N<sup>W</sup>.  
Boundaries of .....  
Garden Area ..... G.A.)

GENERALISED GEOLOGICAL SECTION

ACROSS

**LALLA ROOKH**

PILBARA G. F.

BY **G. GIBB MAITLAND**

GOVERNMENT GEOLOGIST

1903



Length of section about 140 chains  
NOT DRAWN TO SCALE

ALLUVIAL DEPOSITS RECENT		DIABASE		GREENSTONE SCHISTS & ALLIED ROCKS		ARCHAEO		GRANITE		LAMINATED FERRUGINOUS JASPER		QUARTZITES, GRITS & CONGLOMERATE		CAMBRIAN?
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R. H. Smith del.  
2/19/04.





shaft has been sunk upon a north-and-south reef, which traverses the lease for about 400 feet north from the shaft, and which extends for a considerable distance beyond the northern boundary of the lease, but how much farther has not been determined. The reef underlays west at an angle of about 45 degrees. The reef has been opened along the outcrop for about 20 feet north from the shaft to a depth of about 8 feet; and about from 3 to 4 feet of good solid quartz is exposed. The shaft is 46 feet deep, and at the foot of the south face the thickness of the reef is 1 foot 9 inches. A drive about 37 feet in length has been carried northwards from the foot of the shaft, and the reef has been worked out to a depth of from 10 to 12 feet. The reef shows slickensided faces, pointing to a vertical movement subsequent to the formation of the deposit itself. As seen in the face of the drive, the reef attains a thickness of about 3 feet. This reef apparently peters out on the surface to the south of the shaft, and may possibly be cut off by the north-west reef in the southerly shaft. The quartz is banded, containing a little iron pyrites and free gold. Samples of my own collection [5381], assayed in the Survey Laboratory, yielded a return of 2 ozs. 2 dwts. 11 grs. of gold to the ton.

The reef worked in number (2) shaft outcrops for a distance of about 150 feet, when it appears to be cut off by a fault trending generally north-east. Number (2) shaft has been carried down 36 feet on an underlay of 45 degrees to the west, and the width of the stone exposed is 5 feet 7 inches; but beyond opening the reef in the shaft no further work has been done. What is believed to be the continuation of this reef makes its appearance at a point about 300 feet to the north-east along the line of the fault. This extension of the reef trends south-easterly for about 500 feet, as far as the southern boundary of the lease, and for a farther distance of 600 or 700 feet, when it disappears beneath the alluvial flat of Lalla Rookh Creek. The reef does not reappear on the south side of the creek, and it may be that the bold cliff which marks its outcrop on the north bank of the creek is a line of fault parallel to that which traverses the central portion of the Bergamina Lease. At one spot on its south-eastern extension the reef measures 30 feet from wall to wall. No work, however, has been done upon it.

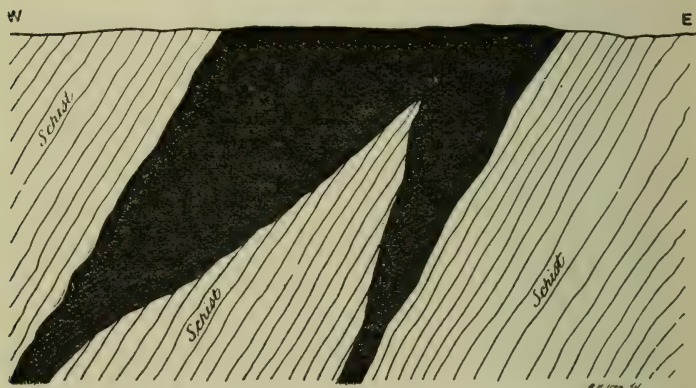
*Table showing the Yield of the Bergamina Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1902	.	.	.	.	88·00	53·00	·60
1903	.	.	.	.	98·00	48·00	·49
Total . . .					186·00	101·00	·54

ALMA NORTH, G.M.L. 602.—There are two reefs upon this property. The most westerly reef is situated a short distance to

the east of one of the tongues of an intrusive diabase, and has an average strike of N. 40 E. A vertical shaft 18 feet deep has been sunk on the reef, but, being inaccessible at the date of my visit, no particulars are ascertainable. There was a little stone at grass. The quartz, so far as could be judged from the stone in the dump, contained small quantities of pyrites. What may be called the main reef in this property enters the lease on the north-east angle, and continues to the south with more or less regularity for a considerable distance. It has been opened up at several places, but no serious work has been done upon it. An assay of a characteristic sample [5383] from the cap of the reef yielded at the hands of the Mineralogist and Assayer a return of 1 oz. 1 dwt. 6 grs. of gold to the ton. The quartz contained a small quantity of iron pyrites in addition to bands of a siliceous oxide of iron.

FIG. 10.



SECTION ACROSS THE ALMA NORTH EXTENDED G.M.L. 603 LALLA ROOKH PILBARA G. F.

ALMA NORTH EXTENDED, G.M.L. 603.—The main reef traverses that half of the lease which is not covered with the modern alluvium of Lalla Rookh Creek. A shaft (*a*) has been sunk to a vertical depth of 14 feet 6 inches, and the section of the reef is as shown in the above section, Fig. 10. The thickness of the reef at the shaft is 9 feet, and as it is followed down it bifurcates, one leg being 2 feet 9 inches, and the other 1 foot thick, respectively.

Beyond sinking the shaft, no other work appears to have been done. There is a little stone lying at grass, which, on being carefully examined, contains a little iron oxide and pyrites, together with a small proportion of green carbonate of copper. At a point about 7 feet south of the shaft the reef widens out to a measured thickness of 25 feet, but it rapidly thins out as it is followed southwards.

ALMA, G.M.L. 592.—The name of this lease implies that it contains the continuation of what may be called the Alma Main



Reef, which is so well developed in the property to the north, but there is no evidence to that effect, as may be seen by an inspection of the geological map of the district. The occurrence of an east-and-west fault renders such a supposition improbable, unless the north-easterly leg of the reef may be connected therewith. Near the north-west angle of the lease is a quartz reef trending 284 degrees, outcropping for a distance of over 100 feet, and which has been opened up in two places. The measured underlie of the reef is 42 degrees to the south. Near the western end of the outcrop the reef bifurcates, one branch trending to the north-east. The quartz, which is of the usual type, measures 1 foot 6 inches in thickness. No work has been done upon the reef. The country rock of this reef is a somewhat calcareous greenstone schist.

THE REWARD CLAIM, R.C. 112.—This lease is the principal one on the field, and is traversed by two fairly well-defined quartz reefs, known respectively as the North and South Reefs, in addition to others of minor importance. The western portion of the property contains a mass of intrusive diabase, the continuation of which occupies a large portion of the surface of the Kitchener Lease on the west. The greater portion of the surface of the Reward Claim is occupied by schists of the type prevailing in other portions of the field.

The plan and sections of the mine have been reduced from the drawings supplied by the owners of the property; these are reproduced on the scale of 100 feet per inch. Plate I.

Main shaft No. 1 on the south reef had been carried down to a vertical depth of about 150 feet. In the shaft, as shown in the section, Fig. 11, the intrusive diabase, which outcrops at about 65 feet to the north, entered the shaft at 65 feet on the north, and passed out of it at 72 feet on the south side. The diabase occupied the whole shaft to a depth of about 12 feet below the level of the crosscut put in to the south at a depth of 150 feet below the surface. The country beneath the greenstone is schist of the usual type.

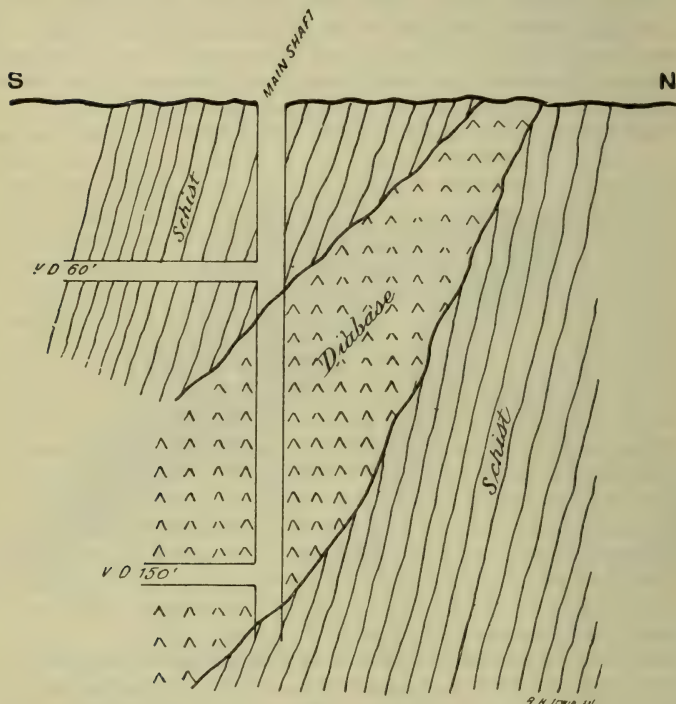
The crosscut at 150 feet had been carried south for a distance of 35 feet at the date the property was visited, with the object of intersecting the main south reef. The crosscut was carried through greenstone. The position of the main shaft is very near what may be called the feather-edge of the reef, *i.e.* near the eastern end of the quartz lens, and although there appears to be no sign of it outcropping, it is possible that the trend of the feather-edge underground may be to the east; in which case the crosscut would be expected to intersect it, if continued.

The question of the extension of the south reef underground at this point in a large measure depends upon the relation which the intrusive diabase bears to the fracture system which resulted in the formation of the fissures occupied by the quartz reefs. So far as the evidence of the field mapping is concerned, it appears that the south reef, as seen in the Kitchener G.M.L. 569, does not traverse the diabase. This, however, may be due to differences in the

nature and texture of the two rocks; the diabase, being much more compact and tough, might not readily admit of the formation of fractures of any extent or width to the westward, as may be seen by an inspection of the geological map of the field.

One hundred and five feet to the south of the main shaft on the south reef is a main open-cut and from which an irregular

FIG. 11.



SECTION IN MAIN SHAFT ON SOUTH REEF REWARD CLAIM 112 GML LALLA ROOKH.  
PILBARA G F.

quartz reef has been worked for a distance of about 100 feet along the strike and to a depth of about 20 feet below the surface. It is the reef occurring in the open-cut which the southern crosscut from No. 3 shaft on the south reef is designed to intersect.

The workings on the north reef are fully shown on the plan and sections of the mine. Some good pyritous stone, said to assay up to 30 oz. of gold to the ton, has been obtained from the reef, but at the date of my visit developments had not been carried sufficiently far to show its exact extent. A good deal of work has

been done upon this reef, which has been opened up in three shafts, Nos. 1, 2, and 3, but it is only in the vicinity of shafts 1 and 2 that any ore has been stoped out. In No. 3 shaft the north reef cut out at 18 feet from the surface by a fault hading to the eastward. From the foot of the shaft, which is 30 feet deep, a crosscut has been put in to the south for a distance of 20 feet through schist of the prevailing type, and a winze has been sunk for a short distance upon a crushed or sheared zone, carrying a little quartz but no defined reef. It may be that this zone represents the continuation of the fault passed through in the shaft.

*Table showing the Yield of the Lalla Rookh Reward Reefs.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1900 . . . . .	700'00	2,394'85	3'42
1901 . . . . .	147'55	520'31	3'52
1902 . . . . .	3,649'00	3,116'35	'85
1903 . . . . .	1,781'00	1,383'05	'77
Total . . . . .	6,277'55	7,414'56	1'18

LUCKNOW, G.M.L. 570.—The Lucknow Lease adjoins the Reward Claim on the east, and the North Reef, worked in the adjoining property, traverses the western portion of the lease.

The main shaft, near the western boundary of the lease, was, at the date of my visit, inaccessible; hence no particulars as to the nature, thickness, and behaviour of the reef could be obtained.

To the east of the main shaft is a hole down about 8 feet, showing two quartz veins, 6 and 8 inches thick respectively, separated by about 12 inches of schist. The veins, which have an average strike of about 256 degrees, are too far to the south to be the continuation of the North Reef.

Further efforts have been made to pick up the North Reef. At a point about 1000 feet east of the north-eastern angle of G.M.L. 570 is a quartz reef, about 2 feet thick, which has been opened up to a depth of about 9 feet, but beyond this no further work has been done on it. This reef is merely a lenticular vein in the schists.

About 60 feet to the east is another hole put down upon what appears to be the same line of reef to a depth of about 5 feet. This excavation exposes two quartz reefs, each about 15 inches thick, and separated by about a foot of schist with thin quartz stringers. The quartz contains a little oxide of iron, but does not prospect well.

The following synoptical table shows the output of the Lalla Rookh centre, so far as is disclosed by the official statistics. From these figures and the descriptions above given, it will be noted



that the gold production of Lalla Rookh is virtually that of one mine:—

*Synoptical Table showing the Yield of the Lalla Rookh Reefs.*

Name of Reef, &c.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Bergamina, G.M.L. 606 . . .	186·00	101·00	·54
Kitchener, G.M.L. 569 . . .	38·50	37·10	·96
Lalla Rookh, R.C. 112 . . .	6,277·55	7,414·56	1·18
Sundry Claims . . . . .	30·45	50·30	1·65
Total . . . . .	6,532·50	7,602·96	1·16

### B.—North Pole

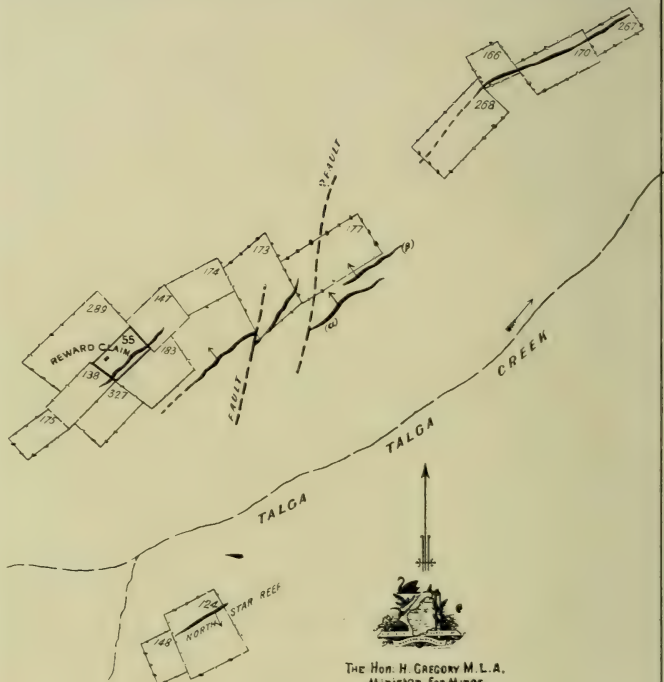
(See *Frontispiece*.)

Leaving the camp at the crossing of the Shaw River, about 4 miles from Lalla Rookh, a traverse was made as far as the now abandoned workings at North Pole. For some miles the country on either bank of the river is occupied with quartzites and conglomerates, which occur in such great force to the south of Lalla Rookh. Excellent sections in the cliffs, on the river bank, demonstrate the folded and faulted nature of the sedimentary rocks; these occupy the country almost as far as the site of the Old Battery at North Pole. A section in the vicinity shows the quartzite beds faulted against the schists and allied rocks which occupy the country in the vicinity.

The old workings are situated in some exceptionally rugged country, through which creeks run in deep, narrow gorges. The workings are situated on the flanks and summits of the ridges. The country rock of the field appears to be greenstone and its transmuted varieties.

A very conspicuous reef upon which a little work had been done runs up at the back of a razor-backed ridge, on a bearing of 71 degrees. The quartz is white in colour, and cubical cellular cavities point to the presence of pyrites in the stone. The reef is not very thick. On the summit of the hill is a peg marked 453, which probably marks the corner of the old North Democrat Lease. The reef forming the crown of the hill bears 58 degrees. About 250 feet to the west of this is another parallel and equally persistent reef. From this point we travelled generally eastward, passing numerous abandoned and inaccessible workings, and followed down a gully, which, on emerging from the range, continued its course to the Shaw River over granite country. The section exposed shows that the greenstone belt is about 3 miles wide.





THE HON. H. GREGORY M.L.A.  
Minister for Mines.

SKETCH PLAN  
SHEWING

THE AURIFEROUS QUARTZ REEFS  
OF

**TALGA TALGA**  
**PILBARA G.F.**

BY

**Gibb Mailand**  
GOVERNMENT GEOLOGIST

1903

0 20 40  
SCALE OF CHAINS

EXPLANATION

QUARTZ REEFS	.....	
MINING LEASES	{	NAME OF ..... REWARD CLAIM
		NO OF ..... 55
		BOUNDARIES OF ..... 174
EXTINCT LEASES	.....	

*Gibb Mailand*  
Government Geologist



Writing on the 5th of September, 1898, Mr. Inspector Gladstone stated:—

“At present only one lease is being worked, the ‘Democrat,’ 18 acres, the property of Messrs. Breen and party. The lease consists of part of a range of high hills, intersected with reefs and leaders, all carrying gold in greater or less quantity. About half-way up the ascent a tunnel has been driven east 250 feet. An underlay shaft sunk altogether 180 feet (inclination about 1 in 4) meets the tunnel at 150 feet, and follows the course of the reef, which consists of heavily mineralised quartz, intersected with bands of felsite. The total thickness is about 7 feet, and should give about an average of 4 feet 6 inches of clear stone. A drive has been put in 20 feet in a northerly direction from the tunnel, and at the bottom of the underlay shaft another drive south, also about 20 feet. On the crest of the range is a reef varying in thickness from 1 to 10 feet, and running east and west, on which a shaft has been sunk vertically 90 feet, and 30 feet farther east an underlay. The visible gold is apparently confined to about two chains in length of the reef, and no work has been done beyond breaking with the hammer, but the outcrop extends for a considerable distance, and other shoots may probably be found. Just after leaving on my return journey I was told that McKenzie had discovered payable gold in an outcrop on the direct line of this reef, and distant about two miles west of the first discovery.”

It appears that in 1898 a Tremaine Mill was erected on the banks of the Shaw River, near the mouth of the gully, draining the flanks of the hills upon which the principal workings were situated. The official returns shown in the following table demonstrate that very little stone could have been raised and crushed.

*Synoptical Table showing the Yield of the North Pole Reefs.*

Name of Reef, &c.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
North Pole Democrat, G.M.L. 453 . . . . .	392·00	268·00	·65
Try Again, G.M.L. 575 . . . . .	24·00	56·40	2·35
Total . . . . .	416·00	324·40	·78

### C.—Talga Talga

*(With a Sketch Plan showing the Auriferous Reefs of Talga Talga, Plate III.)*

The mining centre of Talga Talga lies about 15 miles north of the township of Marble Bar, and three miles distant from the Talga Talga River, the position of which is shown upon the 40-chain Lithograph L 70, issued by the Department of Mines. It may be noted in passing, that although this map shows a branch telegraph line and the position of an hotel at the township of Talga Talga, neither of these exist at the present time. An important feature of the place, the Government Well, from which travellers derive their water-supply, is not located upon the plan. It is desirable that these watering places, the location of which is of the utmost importance to travellers and prospectors, should be shown upon all the published plans issued by the Government.

Writing in the year 1894, the Acting Inspector of Mines, Mr. S. J. Becher, informs the Minister for Mines that:—

“Attention was first paid to it (Talga Talga) by dryblowers, and in times past a considerable amount of gold has been won from the gullies. During the past year a very rich creek bed has been worked adjoining the celebrated ‘McPhee’s Reward,’ and some £2000 worth of gold has been found in the wash, occurring in the form of slugs weighing from an ounce up to 10 or 12 lbs., the larger ones carrying, in some cases, over 100 ozs. of gold; these slugs being the débris, in all probability, of past ages from the ‘Reward’ line of reef, in which rich chutes are being worked at the mines.”<sup>1</sup> . . .

The Warden, in his Annual Report for 1896, states that Talga Talga yielded about 2000 ozs. of alluvial gold. There does not appear to have been any separate record kept of the yield of the alluvial gold from this centre, a circumstance which is very much to be regretted.

Talga Talga consists of a series of almost vertical schistose rocks, the general strike of which is north-east and south-west. These schists are covered with volcanic rocks on both the north and south of the workings. The exact relation of these volcanic rocks to the schists has not been satisfactorily worked out owing to the time at my disposal and the lack of adequate topographical maps. About 2 miles to the east of Talga Talga, the staple formation gives place to granite, which occupies the country as far as Duffer’s Creek Well. Sections in this neighbourhood show that the granite is intrusive.

Some of the reefs of Talga Talga contain bands of a greenish-coloured quartz [5389]. This green quartz was tested in the Survey Laboratory, and five possible colouring matters were looked for, viz., the oxides of copper, ferrous iron, chromium, nickel, and vanadium. Copper and vanadium were found to be entirely absent; while strong traces of ferrous iron and chromium occurred, in addition to minute traces of nickel. From these determinations it is inferred that the green colouring is due to minute disseminated scales of either chrome chlorite (Penninite), or chrome mica, (Fuchsite).

### THE REEFS

The following is a description of such of the mines as were open to inspection at the date of my visit:—

ZEPHYR LEASE (formerly known as The Reward Claim, R.C. 55),  $6\frac{1}{4}$  acres.

No large scale plan of the property exists, hence detailed and intelligible description of the various workings on the lease is well-nigh impossible. The Zephyr Reef appears to be along a line of fault.

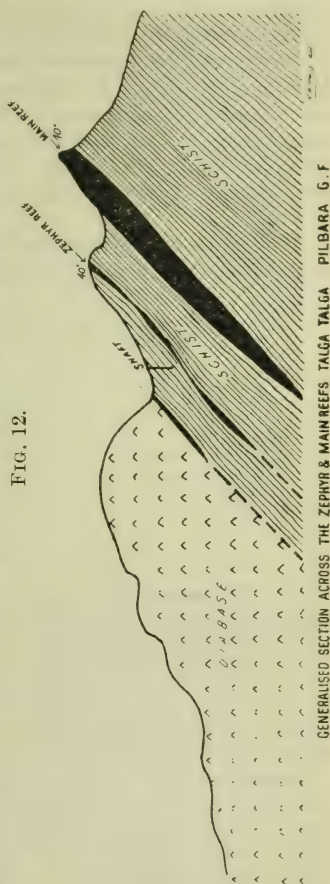
A well-defined quartz reef, underlying at 40 degrees to north 45 west, traverses the whole length of the lease, close to its south-eastern boundary. This reef has been extensively worked in previous

<sup>1</sup> Report of the Department of Mines for the year 1895, Appendix 5. Perth: By Authority, 1896, p. 29.

years by the original owners of the property. The reef occurs in schist country just near the junction of a belt of bedded greenstone which may represent a lava flow. The workings on the reef are all situated on the north-western fall of a comparatively narrow ridge, with a north-easterly trend, upon the flanks of which most of the principal auriferous reefs of Talga Talga occur. About half-way up the hillside a drive has been put in along the reef on a bearing of north 30 east for a distance of 126 feet. At 30 feet from the mouth, the reef has been followed down on the underlie for about 100 feet. As seen underground there is about an average thickness of 1 foot of quartz between the walls. The reef is traversed by a series of vertical fractures trending generally south 30-40 west. From what was shown to me underground, it is apparently along these cracks, or in the vicinity thereof, that the rich patches of gold, for which the reef is noted, occur. What was originally known as No. 1 underlay shaft was put down on a very rich shoot of stone, approximately parallel to the general trend of the fractures above alluded to, and some hundreds of ounces of gold are reported to have been dollied therefrom up to the year 1896. The stone in this underlie averaged from between 2 feet 6 inches to 3 feet in thickness. No. 2 underlay shaft had been put down for a distance of 30 feet, upon another parallel rich chute, contained in a quartz reef about 2 feet 6 inches in thickness. A vertical shaft had been put down below this second underlay shaft to cut the reef.

A vertical shaft had been put down to a depth of 120 feet, in search of water, and at 115 feet a south-eastern crosscut is said to have intersected the reef at 25 feet from the shaft. Water was met with at 50 feet, and while the quality of the water is said to be good, owing to its coming but slowly into the shaft, it cannot be said that the supply is at present sufficient for regular crushing.

When the property was in full working order in 1895 a well-equipped 10-head mill was erected. The property, however, was





abandoned in 1897 by the McPhee's Reward Company, but the original prospector, Mr. Angus McPhee, returned to the scene of his original labours, and unearthed a rich leader on the ground, and, according to his own information, obtained about 500 ozs. of gold therefrom.

At the date of my visit the Zephyr Lease was held by Messrs. Anderson and Cooper, who unearthed a slug, weighing  $5\frac{1}{2}$  lbs., and estimated to contain a little over 30 ozs. of gold. These gentlemen had erected an ingenious crushing plant, driven by the wind as a motive power. A series of photographs were taken of the contrivance, but, unfortunately, owing to the difficulties of transit, &c., none of the negatives used on the trip proved suitable for reproduction.

The following table shows the yield of this lease, so far as can be gathered from official statistics :—

*Table showing the Yield of the Zephyr Reward Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1895 <sup>1</sup> . . . .	223	{ 249·90 <sup>2</sup>	1·17
1896 . . . .	144	{ 666·10	·28
	367	41·00	2·68

It appears that the official returns from this lease are credited to Reward Claim 55, but in subsequent years these are returned under the leases 147 and 148, held by the same company.

NO. 1 NORTH REWARD, G.M.L. 147.—This 9-acre lease adjoins the Zephyr on the north-eastern boundary, and was originally worked by the company which held the Reward Claim (Zephyr). At the date of my visit the ground, in common with all the other properties on the field, was abandoned, and no work had evidently been carried on for some years. The Zephyr Reef enters the property on its south-western boundary, and outcrops for a short distance. A tunnel 15 feet in length had been put in to cut the reef, which was estimated to be 70 feet from the mouth. During the time this lease was held, the labour was for the most part concentrated on the Reward, hence not much work had been done. There appear to have been no crushings from this property.

DAY DAWN, G.M.L. 138.—This property of 9 acres adjoins the McPhee's Reward (Zephyr) on the south-west, and operations would appear to have been confined to the Zephyr Reef, which traverses a portion of the lease. A little desultory work appears to have been done on the property, but owing to its abandonment no details are

<sup>1</sup> The original prospectors are said to have dollied several hundreds of ounces, of which no adequate record appears to have been kept.—A. G. M.

<sup>2</sup> Dollied.

available. There appear to be no separate crushings recorded from this lease, unless such be included in the official statistics under the heading of Sundry Claims.

**TALGA REWARD BLOCK, G.M.L. 289.**—This is a 21-acre deep level or "block" lease, originally taken for the purpose of working the Zephyr (Reward) Reef, on the dip. Practically the whole of the lease is in diabase country, and it was estimated that the Zephyr Reef would be intersected, if its dip remained uniform, at a depth of about 200 feet below the ground level. A considerable amount of trenching had been done upon a small reef, striking north-east and underlying to the south-east. This vein is said to have carried a good deal of fine gold in parts. The property has been abandoned for many years.

**G.M.L. 183 (? MONTE CHRISTO).**—This is a 12-acre abandoned lease, originally taken up on the main prominent quartz reef, which forms such a conspicuous feature in the landscape at Talga Talga, as shown in the generalised section across the Zephyr and Main Reef (Fig. 12). This reef, which forms the summit of the ridge, trends generally north-east and south-west, and underlies at an angle of about 40 degrees to north 55 west. The reef is traversed by two sets of rectangular joints, bearing respectively north and south and east and west. The reef, as measured in its thickest part along the mural face overlooking the creek flowing northwards into the Talga Talga River, is 24 feet thick. The quartz forming the reef is very laminated [5391], being streaked with thin bands of a very dark material, which may possibly be oxide of iron, resulting from the decomposition of fine pyrites. Cellular portions may frequently be noticed along the outcrop, which lends colour to this supposition. An assay of a characteristic sample of the stone [5391], selected without any regard to its representing an average of the reef, yielded, at the hands of Mr. E. S. Simpson, in the Departmental Laboratory, a return of 5 dwts. 8 grs. of gold to the ton. A little desultory work has been done along the outcrop, and a fair quantity of stone taken out and crushed, but the published official returns do not show any yield from this locality, unless it is included under the heading of the yield from Sundry Claims. So far as could be inferred from the condition of the outcrop workings, the ore shoot would seem to be confined to a narrow band of stone, about 2 feet thick, lying about 5 or 6 feet below the hanging wall of the reef. The distance along which the outcrop of the reef can be followed is at least 25 chains. At one point down the dip, however, the reef peters out at 90 feet from the outcrop, and its place is taken by schist of the type prevailing in the neighbourhood of Talga Talga.

**MONTE CHRISTO SOUTH, G.M.L. 327.**—This 9-acre lease is situated in the south-eastern angle formed by leases 138 and 183. A strong, well-defined reef, averaging about 2 feet in thickness, traverses the lease, on a general bearing of about 35 degrees, with a westerly underlie of 30 degrees. No work has been done upon

the lease for many years, nor do there appear to have been any crushings recorded from it.

G.M.L. 173.—The main reef outcropping along the boundary of lease 183 continues without a break as far as the south-west angle of G.M.L. 173, at which point it is traversed by a fault trending generally north and south, with a downthrow to the east of but a few feet. From this point the reef continues without interruption through the lease, and after sweeping round the face of the ridge enters the adjoining property on the north, G.M.L. 177.

G.M.L. 177.—This property was one of the group originally held by the North-West Goldfields Company. A good deal of trenching has been done in several places along the outcrop of the reef, high up on the face of the hillside; and a tunnel, 84 feet in length, designed to intersect the main reef, is said to have passed through a small barren quartz reef at 40 feet from the mouth.

At a point ( $\alpha$ ) shown upon the sketch plan what appears to be the main reef, outcropping in G.M.L. 173, has been faulted to the southward. To the north of this reef, at a point ( $\beta$ ) on the summit of the ridge, is the outcrop of a strong and well-defined banded quartz reef, striking north 55 east. The stone contains bands of brown hematite [5390], some attaining a thickness of about an inch. The quartz contains, in addition, small quantities of iron pyrites. This reef has been opened up along the outcrop and a little stone raised. Samples from the outcrop assayed in the official laboratory yielded but a trace of gold to the ton. There appear to have been no crushings from this property.

A group of four leases originally held by the North-West Goldfields Company lies about 20 chains north-west of the lease 177.

G.M.L. 268.—This is an 18-acre property, upon which practically no work of any moment has been done.

REWARD CLAIM, R.C. 166.—This property comprises 6 acres, and was originally held by Messrs. Breen and Wilson, who, after doing a certain amount of prospecting work, disposed of the property to the North-West Goldfields Company. The original prospectors sank an underlie shaft, and are said to have raised about 20 tons of quartz from the reef. The Company sank an underlie shaft to a depth said to have been about 100 feet, and a tunnel 20 feet in length was put in to intersect the reef, which proved to be about 8 inches in thickness, and to have passed into calcite and dolomite (?), together with small quantities of carbonate of iron. The property appears to have been abandoned for some years, and no work of any consequence carried out.

G.M.L. 170.—This old lease of 12 acres was held by the same Company as that which held the Reward Claim, R.C. 166. Several short drives were put in on the sides of the hill facing west, where the reef outcrops, and an underlay shaft of a depth unknown put down on the reef outcropping on the summit of the hill. A water



shaft of unknown depth was sunk on the flat below the hill adjoining the site chosen for a battery, but no particulars are available in connection with it. The country rock on the lease is very hard schist. A crushing of 26 tons, yielding 33 ozs. of gold, or at the rate of 1·26 ozs. per ton, has been officially recorded from this property.

G.M.L. 207.—A little desultory prospecting work has been done upon this lease, but so far nothing of any importance has resulted therefrom.

GALATEA, G.M.L. 311.—This property lies about 64 chains almost due east from the Reward Claim, R.C. 166, and its relative position may be seen by an inspection of Lithograph L. 70, issued by the Department of Mines in 1903. Four shafts have been sunk on the lease, in addition to a certain amount of trenching in different portions of the property. The principal work on the lease was concentrated on the northern end of the property. Shaft No. 1 (not shown on the map) is a large prospecting shaft reported to have been sunk to a depth of 16 feet on a large irregular quartz reef, which has an average strike of 40 deg., and a slight underlie to the north-west. The quartz lying at grass is somewhat laminated, with films and bunches of serpentine (a decomposition product of the country rock). Free gold was showing in some of the stone lying at grass at the date of my visit. No. 2 shaft had been sunk to the north to a depth of 12 feet, upon the same line of reef, but without apparently anything of any moment being found. Shaft No. 3, 12 feet deep, was sunk between two small reefs, with the object of intersecting any connecting leaders which might exist, but, being inaccessible, nothing was to be seen of the nature of the sinking. No. 4 shaft was commenced south of the main shaft on the assumed trench of the main reef, but no particulars are available. There would appear to have been no crushings from this lease, unless such be included under the heading of sundry claims shown in the official returns.

STAR OF THE NORTH, G.M.L. 124.—An 18-acre lease lying about half a mile due south of G.M.L. 183, taken up for the purpose of exploiting on E.N.E. trending reef, underlying at a comparatively low angle to the S.W. The property, long since abandoned, was originally held by the Consolidated Gold Mining Company of Western Australia. So far as may be seen at the present time, it appears that the work done upon the lease consisted of a tunnel put in along the strike of the reef, commencing at a point on the gully in which it outcrops. A winze has been put down on the underlie north-west from the tunnel, at a point 73 feet from the brace, as shown in Fig. 13.

A vertical shaft has been put down 56 feet to the reef, from a point about two chains north of the outcrop of the reef. Levels have been driven a few feet east and west. The quartz is very white, is traversed by thin green veins of chlorite (?), and carries small quantities of carbonates and sulphides of copper. Flat veins of

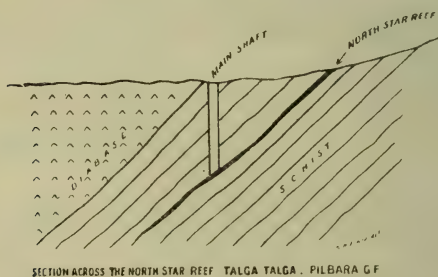
carbonate of iron are occasionally to be seen in the stone. Free gold is showing in the stone lying at grass. The following table gives the return of the crushings recorded from this mine:—

*Table showing the Yield of the Star of the North Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . . . .	18·50	19·00	1·03
1897 . . . . .	97·00	115·74	1·19
Total . . . . .	115·50	134·74	1·16

No. 1 SOUTH STAR OF THE NORTH, G.M.L. 148.—This property adjoins the one last mentioned on the west, and was originally held by the Shaw River Gold Mining Company, but has apparently been abandoned for many years. So far as may be seen at the present time, it appears that an underlie shaft of unknown depth had been put down upon a small irregular reef, striking east and west and underlying to the north. A vertical shaft 25 feet in depth had been sunk to meet the underlie, which is said to have

FIG. 13.



been continued for a distance of 27 feet from the foot of the vertical shaft. A drive is stated to have been put in 17 feet to the north, but the workings being inaccessible, no particulars are available. About 10 tons of quartz from the underlie shaft and stopes are said to have been crushed and yielded a return of 2 oz. of gold per ton. It may be noted in this connection that in the Annual Mining Statistics for 1897, published by the Government, there appears a return from G.M.Ls. 147, 148 (McPhee's Reward), 367 tons yielding 957 ozs. of gold, or at the rate of 2 oz. 12 dwts. 3 grs. per ton; it is more than probable that this represents the yield from the MCPhee's Reward Claim R.C. 55, now known as the Zephyr Lease.

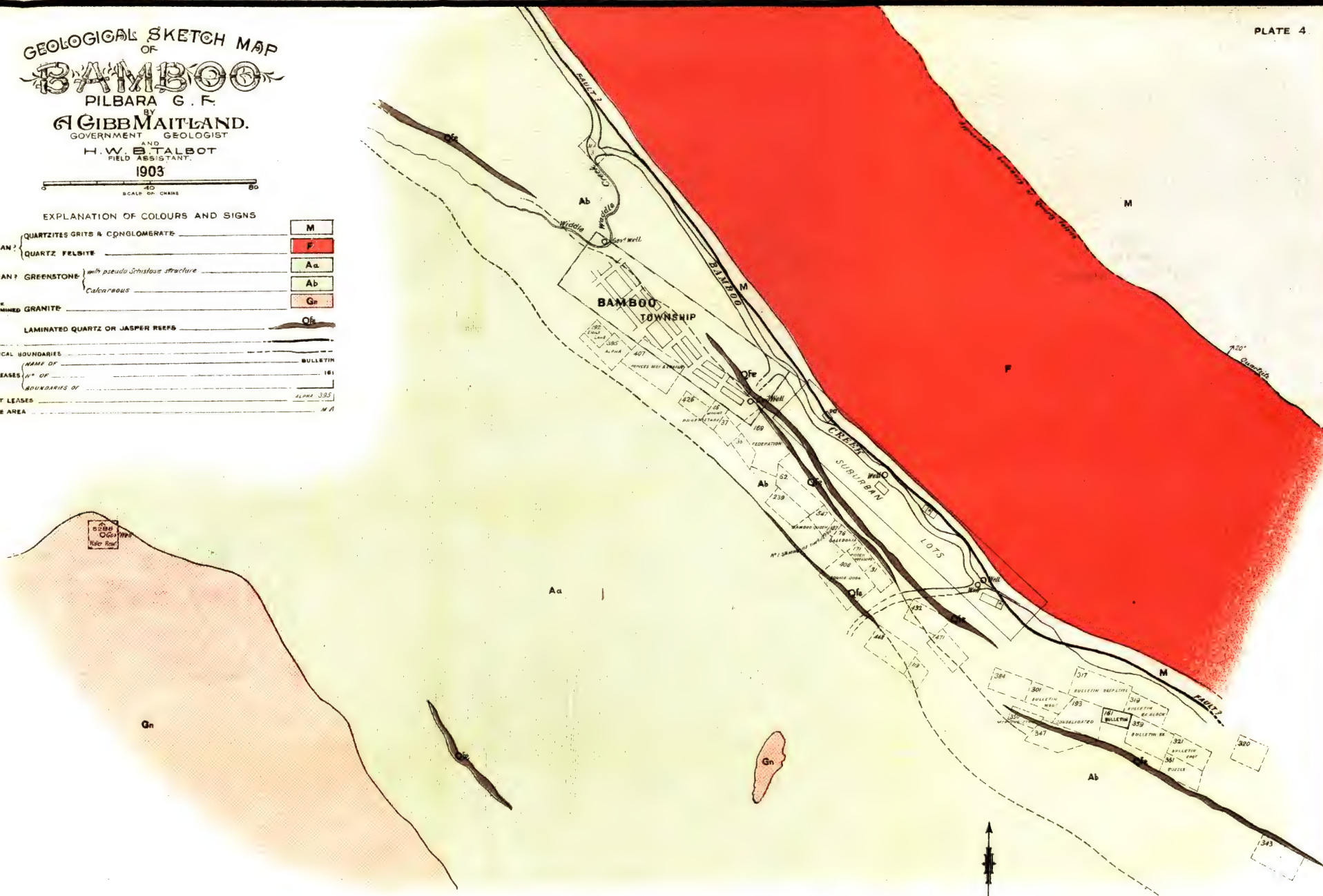


GEOLOGICAL SKETCH MAP  
OF  
**BAMBOO**  
PILBARA G. F.  
BY  
**GIBB MAITLAND.**  
GOVERNMENT GEOLOGIST  
AND  
**H. W. TALBOT**  
FIELD ASSISTANT.  
1903

SCALE OF CHAINS  
0 40 80

EXPLANATION OF COLOURS AND SIGNS

QUARTZITES GRITS & CONGLOMERATE	M
QUARTZ FELSITE	F
ARCHÆAN? GREENSTONE	Aa
with pseudo Schistose structure	Ab
Calcareous	Gn
AGE UNDETERMINED GRANITE	Ql
LAMINATED QUARTZ OR JASPER REEFS	QFe
FAULT	
GEOLOGICAL BOUNDARIES	
NAME OF	BULLETIN
MINING LEASES	161
BOUNDARIES OF	
EXTINCT LEASES	ALPHA 335
MACHINE AREA	M 11



M = QUARTZITES, GRITS AND CONGLOMERATES (2 Columns). F = QUARTZ FELSITE (2 Columns). D = AMYGBALOID DIABASE (2 Columns). A = SCHISTS (2 Columns). Gn = GRANITE (Age undetermined). Q = QUARTZ REEFS. QFe = JASPER (Chert) VEIN.

NOT DRAWN TO SCALE  
GENERALISED SECTION ACROSS BAMBOO.



THE HON. H. GREGORY M. L. A.  
Minister for Mines

*Alib Maitland*  
Government Geologist



MAP



D.



IGNS

	M
	F
	Aa
	Ab
	Gp
	Qfs

The following table shows the gold yield of Talga Talga, so far as it can be ascertained from the official statistics:—

*Synoptical Table showing the Yield of the Talga Talga Reefs.*

Year.	Name of Lease, &c.	Ore Crushed.	Gold therefrom.	Rate per Ton.	Total Ore Crushed.	Total Gold therefrom.	Average Rate per Ton.
		Tons.	Ozs.	Ozs.	Tons.	Ozs.	Ozs.
1898	General, G.M.L. 485	43·00	44·60	1·03			
1899	„ „	11·50	7·90	·68	54·50	52·50	·96
1897	Jubilee, G.M.L. 458	91·00	137·00	1·50			
1898	„ „	33·00	45·90	1·39	124·00	182·90	1·47
Previous to 1897	McPhee's Reward, Ltd., G.M.L. 55 .	367·00	957·00	2·60	367·00	957·00	2·60
Previous to 1897	Star of the North, G.M.L. 124 .	18·50	19·00	1·03			
1897	„ „	97·00	115·74	1·19	115·50	134·74	1·16
1898	N.W. Goldfields, Ltd., G.M.L. 170 .	26·00	33·00	1·26	26·00	33·00	1·26
Previous to 1897	Sundry Claims .	96·00	456·00	4·75			
1899	„ „ .	45·00	89·95	1·99			
1901	„ „ .	9·25	24·10	2·60			
1902	„ „ .	54·40	82·09	1·50	204·65	652·14	3·18
	Totals .	...	...	...	891·65	2012·28	2·25

### D.—Bamboo

*(With a Geological Sketch Map and Section, Plate IV.)*

The mining centre of Bamboo lies about 40 miles to the north-east of Marble Bar, and is situated on Bamboo Creek, one of the tributaries of the De Grey River. The centre is practically abandoned; at the date of my visit there existed only the post office, in charge of one officer. The office was in telephonic communication with Marble Bar.

No work of any description, except a little prospecting by four men at Nuggety Gully, was being carried on at the date of my visit, the number of abandoned workings extending continuously over a comparatively narrow strip of country for a length of a little over four miles. The abandoned shafts and other workings forcibly attest the activity which at one time prevailed at this centre. Writing in 1894, Mr. S. J. Becher, the Acting Inspector of Mines for the district, stated with reference to Bamboo Creek:—

“Although of more recent development than Marble Bar, can boast of a large extent of workings, and a very considerable amount of systematic mining development and progress. Several individual properties have been

proved to be very valuable, and there is not a doubt that many more will yet rise above the average and come to the front. There are two batteries at work and a third is being erected. English capitalists have, during the past year, secured several groups of first-class properties, and Queensland capital has also played a part in the progress of the field. There is a healthy tone of solid work and progress about the place, which shows that its resources are good. Two hotels and several boarding-houses have crowded tables. The mail service is once a fortnight, and there is a post and telegraph office.

"Crushings from the various mines are consistently good, and the output of gold is large, considering the infancy of the field. Among the best mines may be mentioned the Bulletin, Bamboo Queen No. 1, and Mount Prophecy.

"The water-supply is obtained from wells, and seems to be abundant. Timber is very expensive, owing to the distance from which it has to be carted. The character of the country is very rugged, and the township is situated in a deep valley, through which the Bamboo Creek runs.

"The main range of granite and granitic rocks striking north-east lies a little to the east of the field, the mines and workings for the most part being on two lines or belts of 'opaline' and diorite ranges, running parallel to the main range. The backbone of one of these lesser ranges is an immense quartzite, or quartz and jasper dyke. Traces of gold have been found in this dyke, and prospecting work is being carried out thereon. The present field is about three miles long by three-quarters of a mile wide, but there is but little doubt that it will extend greatly as time goes on, especially south-eastwards towards the Little De Grey River. The auriferous quartz of the district is characteristic, and is highly mineralised with iron, copper, lead, and manganese. Calcite and carbonate of iron veins are locally considered favourable indications of gold. The reefs, taken as a whole, are small on the surface, but widen out well in depth. This is particularly well shown in the celebrated Bulletin Mine, where the lode in places widens out to 10 or 12 feet in thickness at about 60 feet in depth. The gold occurs in rich, coarse chutes, and also well disseminated throughout the stone. Like most of the other fields, Bamboo Creek owes its origin to alluvial gold finds. Much alluvial gold has been won from the gullies in the form of slugs and nuggets, as well as fine gold."<sup>1</sup>

Reporting upon the work of the Pilbara Goldfield in 1896, the Warden writes:—

"One of the most striking features of the present condition of mining in this field is the steady developmental work being prosecuted by private, as well as company, holders of leases. Foremost in this branch of work is that part of the Pilbara Goldfield known as Bamboo Creek, where a large amount of dead work is being undertaken."<sup>2</sup>

The same officer, reporting to the Minister upon the field in 1897, writes that Bamboo

"has a population of about 250. It has two hotels, two stores, Post and Telegraph Office, and a weekly mail service to Marble Bar. There are three batteries. The reefs are generally well defined, and seem to be of a permanent character. The Bulletin Proprietary Company are sinking a straight shaft on their block claim, and intend going to a depth of 500 feet to cut the Bulletin Reef. This will be the deepest shaft on the field, and will go far to prove the permanency of the reefs in this particular locality. Timber is obtained at a distance of four miles, at a cost of £2 per cord. There is good

<sup>1</sup> Report of the Department of Mines for the year 1895; Appendix 5. Perth: By Authority, 1896, pp. 28-29.

<sup>2</sup> Report of the Department of Mines for the year 1896. Perth: By Authority, 1897, p. 59.



water at an average depth of 60 feet to 80 feet. The yield of gold for 1897 is 1712 ozs. out of 688 tons of stone." . . .<sup>1</sup>

In his account on the prospects of the field for the following year, the Warden informs the Minister that—

"A serious drawback to mining has been occasioned by the failure of some of the few mining companies on the field and the necessity of others to reconstruct, the cause of this being, in my opinion, the result of not providing adequate working capital. This is particularly noticeable at Bamboo Creek, where the shaft sunk on the Bulletin Proprietary Company's block has been delayed. This shaft was intended to cut the Bulletin Reef, and would have gone far towards proving the permanence of the reefs in this locality or otherwise, a test which has never yet been put to a reef on this field."<sup>2</sup>

The succeeding year finds the Warden writing to the Minister on the progress of Pilbara for 1899, as follows:—

"Bamboo Creek has been under a cloud, the silver lining of which is showing, it is hoped, by the resumption of work on the Bonnie Doon, a property belonging to an English Company."<sup>3</sup>

In 1900 the same record of a decline at Bamboo is reported by the Warden—

"There were only two companies (holding leases at Bamboo Creek) operating, and they did very little work, being crippled for want of capital."<sup>4</sup>

Since that date the field has gradually declined until, at the present time, it is practically abandoned, despite the fact that the average of the crushings from the district has been 1·91 ozs. per ton, obtained from the milling of over 10,000 tons of ore.

## GENERAL GEOLOGICAL FEATURES

As may be seen by an inspection of the geological sketch map and the generalised section across the field, the auriferous series of Bamboo is contained within a narrow strip of greenstone schists and allied rocks, which flank the south-western margin of a belt of quartzites, grits, conglomerates, with interbedded felsitic lavas.

The schists, so far as can be seen in section, are everywhere practically vertical, or at any rate, inclined at high angles, and trend generally north-west and south-east. They occupy a width on the surface of about three miles, the south-western boundary being formed of granite which is clearly intrusive, for it sends out tongues and bosses into the schists. So far as mining operations have at present been carried, it appears that the auriferous reefs are confined to that portion of the schists, forming a strip not exceeding half a mile in width, and which weather into calcareous rocks [5382], which at first sight might pass for limestones.

Time did not admit of any investigations being made as to the effect of the granite intrusion upon the schists in the vicinity of the

<sup>1</sup> Report of the Department of Mines for the year 1897. Perth: By Authority, 1898, p. 23.

<sup>2</sup> *Ibid.*, 1898. *Ibid.*, 1899, p. 19.

<sup>3</sup> *Ibid.*, 1899. *Ibid.*, 1900, p. 105.

<sup>4</sup> *Ibid.*, 1900. *Ibid.*, 1901, p. 112.

mass. Although the whole of the Archæan (?) area, as defined on the geological sketch map, is shown as consisting of schists, there are patches of unfoliated greenstones which are too small to be shown, owing to the smallness of the scale. This is particularly the case in the vicinity of the Bulletin Mine, G.M.L. 161. Here occurs a rock [5405], the composition of which is shown in the table on page 7. The rock, which is a diabase, forms the country rock of the Bulletin Reef. There seems good reason to believe that some, at any rate, of the schists are merely transmuted varieties of massive greenstones, a few patches of which occur in the vicinity. Much more detailed work than was considered expedient will be necessary before this and other cognate points can be properly investigated.

The schists are traversed by several persistent belts of laminated quartzites (cherts?) of great thickness, which form very conspicuous features in the landscape. The most prominent one of these measured at least 30 feet in width. It is in close proximity to these that most of the auriferous reefs yet opened up occur.

The granite occupies an extensive area of country, and is particularly well developed in the vicinity of Water Reserve 8288. Another smaller mass, about 30 chains in length and 10 in width, rises through the schists at a point about 130 chains west of the Bulletin Mine, G.M.L. 161. So far as observations have been carried in this locality, the granite does not penetrate the much newer sedimentary beds and their associated volcanic rocks; it may therefore be inferred to be of greater age than the sedimentary rocks.

The sedimentary rocks are bounded on the west by a powerful fault, which practically forms the channel in which Bamboo Creek flows. The relation of the series to the schists is diagrammatically represented in the generalised sketch section across the field accompanying the geological sketch map.

A narrow strip of quartzites, conglomerates, and shales outcrop along the bank of the river, and the relation of these to the rocks above and below them can be seen in many sections. At one point near the south-eastern boundary of the Suburban Lots area a series of almost vertical grey shales are seen to rise conformably beneath the sandstones and quartzites, which flank the northern half of the Watershed, and to be faulted against the schists and allied rocks.

Resting upon the quartzites are a series of beds of quartz felsite [5404] representing a steep, rugged face to the west, and which form an outcrop about 2 miles in width. These beds dip to the north-east at angles varying from 20 to 30 degrees. Towards the southern end of the creek the base of the lavas is about on a level with the channel, whilst the highest point to which they rise is about 150 feet. These lavas pass conformably beneath the higher quartzites, which dip at angles closely approaching 20 degrees, as shown in the section which accompanies the map.

Near the old battery site, M.A. 3, on the lower reaches of Bamboo Creek, a bed of amygdaloidal diabase (?) rises from

beneath the quartzites, from which it is probably separated by a fault, occurring beneath the alluvium of the creek. Its relation to the greenstone schists and allied rocks is not clear, its dip, however, is coincident both in amount and direction with that of the sedimentary rocks.

The area this rock occupies is too small to admit of its being shown on the geological map, though it has been included in the geological section.

A large laminated quartz (chert?) vein of considerable thickness, forms the backbone of the country near the head of Bamboo Creek. The highest point of the ridge is alongside the north-eastern boundary of G.M.L. 343, and from the summit of the ridge an excellent view of the country to the north can be obtained. To the northwards the sedimentary rocks are seen to occupy the surface and to be disposed in a large synclinal trough, a conspicuous point on the north-eastern lip of the basin bearing 74 degrees, and distant, as estimated, about 8 miles.

### THE REEFS

Although practically none of the mines at Bamboo were accessible at the date of my visit, the following information extracted from the manuscript reports of the Inspectors of Mines (not previously published) give some idea of the state of development and other cognate points at the time these officers visited the properties; the notes, however, make no pretensions to being more than that.

In order to facilitate description the mines are described in geographical order, commencing at the north-westernmost end of the leases. The position of the various properties is shown on the geological sketch map attached, or on Lithograph L. 80, issued by the Department of Mines.

EMILY JANE, G.M.L. 192 (formerly known as the Thistle).—A shaft had been put down 30 feet to the level of the tunnel driven south-westwards from the foot of the ridge upon which the reef is situated. (B.)<sup>1</sup> There appear to have been no crushings recorded from this mine.

ALPHA, G.M.L. 395.—A shaft had been sunk to an unknown depth upon the outcrop of the main Alpha Reef, and a tunnel driven about 75 feet at a point 150 feet below the outcrop, with the object of intersecting the reef at an estimated distance of 200 feet from the mouth. (B.) The only crushing recorded from this mine is one during the year 1899, when four tons of quartz were reported to have yielded 8·40 ozs. of gold, being at the rate of 2·10 ozs. per ton.

PRINCESS MAY AND CHARLIE, G.M.L. 407.—This 24-acre lease was originally held by the Pilbara Goldfields Company, which owned several other properties on the field. There appear to have

<sup>1</sup> The letters in heavy type throughout this portion of the report refer to the manuscript reports of (B) the late Mr. S. J. Becher, and (G) Mr. R. G. Gladstone, both of whom filled the position of Inspector of Mines at different periods.



been two reefs upon this property, known, respectively, as the Princess May and the Charlie.

Upon the Princess May reef, an underlay shaft was put down upon an east and west reef to the north of a tunnel, which had been driven 90 feet, the mouth of which was estimated to be about 30 or 40 feet below the level of the outcrop. The reef is said to have been at all times small but rich. The country rock is schist, which weathers into calcareous rock, locally called limestone.

Upon the Charlie reef, which had an average strike of about north-east, a shaft over 60 feet in depth had been sunk. (B.)

There would appear to have been no crushings from this property unless any such are included under the returns from Sundry Claims, details of which are not specified.

MOUNT PROPHECY, G.M.L. 46 (late G.M.Ls. 46, 49).—This is a 6-acre lease, originally held by a London Company, the Mount Prophecy and Perseverance Gold Mines, Ltd., but which appears to have been abandoned many years ago. The reef appears to have been narrow and irregular as followed down, although it was very wide in the outcrop, but despite this a good deal of work appears to have been done, and over 4000 tons of stone has been unearthed in both driving and stoping, all of which has been officially reported as returning over 2 ozs. to the ton. (G.)

The reef outcrops near the summit of a ridge, and a tunnel has been put in at about 75 feet below the outcrop; at 65 feet from the mouth the reef was met with, and was stoped up to the surface. The reef proved to be only 12 inches in width and very irregular. A winze was put down 75 feet from the end of this level upon a thin vein of quartz. A second tunnel had been put in at the base of the ridge, at a point estimated to be 180 feet below the outcrop. It was anticipated intersecting the winze above mentioned at 280 feet. A 10-head mill was erected on a machine area close to the creek, about half a mile from the workings. (B.)

So far as may be judged by the official returns, the mine has had a good record, but owing to the state of the workings it was impossible for me to ascertain anything as to the nature and behaviour of the reef underground.

The following table shows the yield of the property so far as has been officially reported:—

*Table showing the Yield of the Mount Prophecy Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . . .	925·00	2,350·00	2·54
1897 . . . . .	142·00	355·00	2·50
1898 . . . . .	272·00	728·50	2·67
1899 . . . . .	221·00	492·00	2·22
1900 . . . . .	97·50	147·10	1·50
Total . . . .	1,658·00	4,072·60	2·45

FEDERATION, G.M.L. 169.—A 25-acre lease held by a Queensland Company, known as the Bamboo Creek G.M. Co. The reef runs about east and west, and a good deal of work would appear to have been done. A shaft had been sunk to a depth of 75 feet, and a level at that depth was driven for some distance to the north-west, following a well-defined and good hanging wall. The reef, however, is reported to have been very irregular and bunchy. (B.)

There do not appear to have been any crushings recorded unless such are included under the returns from Sundry Claims, details of which are not specified.

BAMBOO QUEEN, G.M.L. 547 (formerly G.M.L. 409).—This property included The Reward, G.M.Ls. 49, 50, and 300. Some very rich dollying stone is said to have been taken from the outcrop of the reef by the original prospectors of the property. Besides old superficial workings a main shaft had been sunk to a depth of over 40 feet upon the Reward portion of the property, whilst the Queen portion of the property a main shaft 80 feet in vertical depth had been sunk in addition to a considerable amount of unsystematic old workings. (B.)

All the workings being inaccessible no particulars as to reefs, &c., were available. The following table gives the yield of the Bamboo Queen and Reward:—

*Table showing the Yield of the Bamboo Queen Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . .	1,170·00	2,231·00	1·90
1898 . . . . .	120·00	68·00	·56
1899 . . . . .	100·50	137·80	1·37
Total . . . . .	1,390·50	2,436·80	1·75

It is not quite clear whether the yield from L.C. 131, known as Bamboo Queen, in 1903 should be included in the above return. The official figures for 1903 show that 30 tons of ore yielded 63·85 ozs. of gold, or at the average rate of 2·13 ozs. per ton.

No. 1 SOUTH KING OF TIMBUCTOO, G.M.L. 187.—A small lease of three acres, taken up to exploit a north-west reef having a slight underlay to the north-east. The reef is believed to be the continuation of the Queen. There appear to have been two shafts put down upon this lease—(a) an underlay 82 feet in depth, with a western crosscut, and (b) an underlay 40 feet in depth, with short drives both north and south. The reef is reported to occur in lenticular and irregular masses. The quartz is white, and said to have carried small veins of chlorite, with iron pyrites and a little galena. A 10-head mill was at one time erected on the property. (B.)

The returns from this property are included under the heading of Tasmanian and No. 1 Timbuctoo, G.M.Ls. 71 and 189, and are given in the following table:—

*Table showing the Yield of the Timbuctoo No. 1  
(Tasmanian) Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . . . .	1,311·00	3,271·00	2·49
1898 . . . . .	122·00	131·40	1·07
Total . . . . .	1,433·00	3,402·40	2·36

CALEDONIA, G.M.L. 76.—A 6-acre lease, originally held by the Pilbara Goldfields Company. The reef on the property occurs into large lenticular masses, and a good deal of open-cast work appears to have been done upon it. (B.)

HIDDEN TREASURE, G.M.L. 171.—A property at one time held by the Pilbara Syndicate, Ltd. A prospecting tunnel has been put in to test the country, but beyond the fact that it has been carried about 100 feet, no further particulars are available. (B.)

The following table shows the returns from this property:—

*Table showing the Yield of the Hidden Treasure Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . . . .	60·00	85·00	1·41
1898 . . . . .	36·00	35·00	·94
Total . . . . .	96·00	119·00	1·23

BONNIE DOON, G.M.L. 408.—The reef upon the property has an average strike of north-east with an underlay to the north at 60 degrees. This appears to be a cross line of reef to the main trend of those at present opened up on the district. A shaft had been put down on the reef to a depth of 82 feet, and a reef 6 feet in width met with. There is said to have been a considerable influx of water at the 82 feet level. The quartz of the Bonnie Doon contains a little iron pyrites, oxide of manganese, and a little talc. (B.) When examined by Mr. Inspector Gladstone, the reef then exposed was 10 feet in width. (G.) The crushing returns from this property are included with those from the other leases held by the Pilbara Goldfields Company, viz., G.M.Ls. 62, 76, 406, 408,



471, which renders it impossible to give the yield from each individual property. The following table, however, shows the yield of gold, so far as it can be ascertained from the data supplied to the Government. (B.)

*Table showing the Yield of the Bonnie Doon Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . .	829·00	1,948·00	2·35
1898 . . . . .	1,270·00	1,098·20	·86
1899 . . . . .	122·00	77·65	·63
1900 . . . . .	76·75	53·00	·69
Total . . . . .	2,297·75	3,176·85	1·81

BAMBOO KING, G.M.L. 471.—What was known as the Bamboo Queen workings are situated on a large reef of quartz some 10 feet wide in places, but which when followed down 30 feet petered out. Operations were eventually carried down by a tunnel put in at the base of the hill upon a good sized quartz reef 4 feet in thickness, which is said to have been of low grade, returning little more than 10 dwts. per ton. This reef was followed on the dip until it likewise petered out. (B and G.) The returns from this property are included in those of the leases 62, 76, 406, 407, 408, and 471 held by the Pilbara Goldfields, Ltd., and are given above.

CONSOLIDATED, G.M.L. 193.—An 18-acre lease owned by the Bamboo Consols Gold Mines, Limited. A tunnel has been put in for a distance of 138 feet, and is said to have intersected the reef sunk upon the adjoining underlay. At 78 feet a vertical shaft was sunk, with the object of cutting a wide lode formation showing in the tunnel, about 15 feet in width, said to be the continuation of the Bulletin Reef. (B.)

BULLETIN, G.M.L. 161.—A 6-acre lease, from which 3329·50 tons have been raised and crushed up to the close of 1903, and

*Table showing the Yield of the Bulletin Reef since First Worked.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . .	832·00	2,084·00	2·50
1897 . . . . .	511·50	769·00	1·50
1898 . . . . .	236·00	423·00	1·79
1899 . . . . .	530·00	724·45	1·36
1900 . . . . .	400·00	747·25	1·86
1901 . . . . .	340·00	796·90	2·34
1902 . . . . .	300·00	637·40	2·12
1903 . . . . .	180·00	180·00	1·00
Total . . . . .	3,329·50	6,362·00	1·93

which has yielded 6362·00 ozs. of gold, having an average grade of 1·93 ozs. per ton. No work was going on at the date of my visit, access to the workings could not be obtained, and as there do not appear to be any plans of the workings, no information as to the reef, its character, behaviour, &c., can be given.

**BULLETIN DEEP LEVEL, G.M.L. 317.**—This is a 24-acre “block,” and a main vertical shaft has been sunk with the object of intersecting the Bulletin Reef; no particulars, however, are available, owing to the shaft being inaccessible. Mr. Inspector Gladstone reports that at the date he visited the mine the shaft had been carried down to a depth of 393 feet. (G.)

**BULLETIN EAST, G.M.L. 321.**—A 12-acre block, upon which two shafts have been put down. One had been put down on a reef with a slight underlay to the north. A short distance to the north of this another vertical shaft had been put down 30 feet, and a crosscut of 11 feet had been driven, but no reef had apparently been met with. (B.)

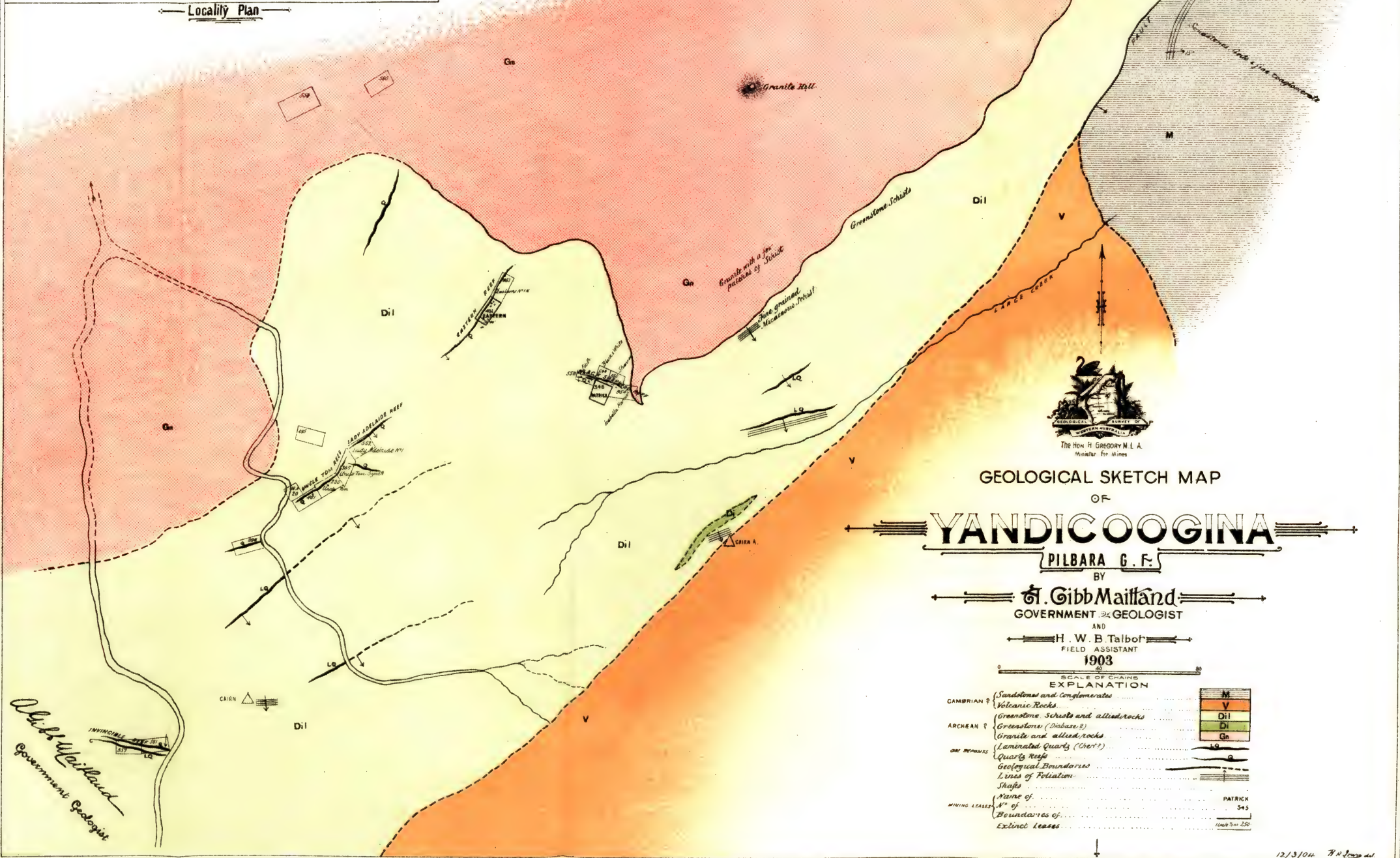
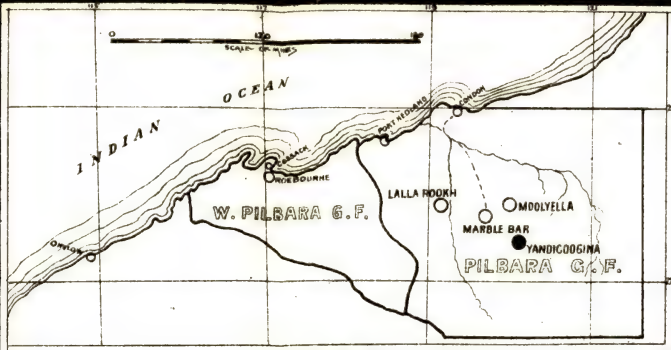
**NUGGETY GULLY CLAIM.**—A claim held by Messrs. Elliott, Ward, and Kale, situated on Nuggety Gully, which lies a short distance to the north-west of Widdle Waddle Creek, had been taken up a short time previous to my visit to Bamboo. An underlay shaft had been put down 25 feet by the present prospectors, on a quartz vein about 6 inches thick. At the foot of the shaft the main reef is joined by another almost vertical vein about 3 or 4 inches in thickness. The stone is auriferous, and some very rich specimens said to have been obtained from the veins were shown to me in camp. The stone contained a little iron oxide, and its facings were coated with dendritic manganese markings.

The following is a synoptical table of the gold yield of Bamboo, so far as may be gathered from official statistics. The figures are up to the end of 1903:—

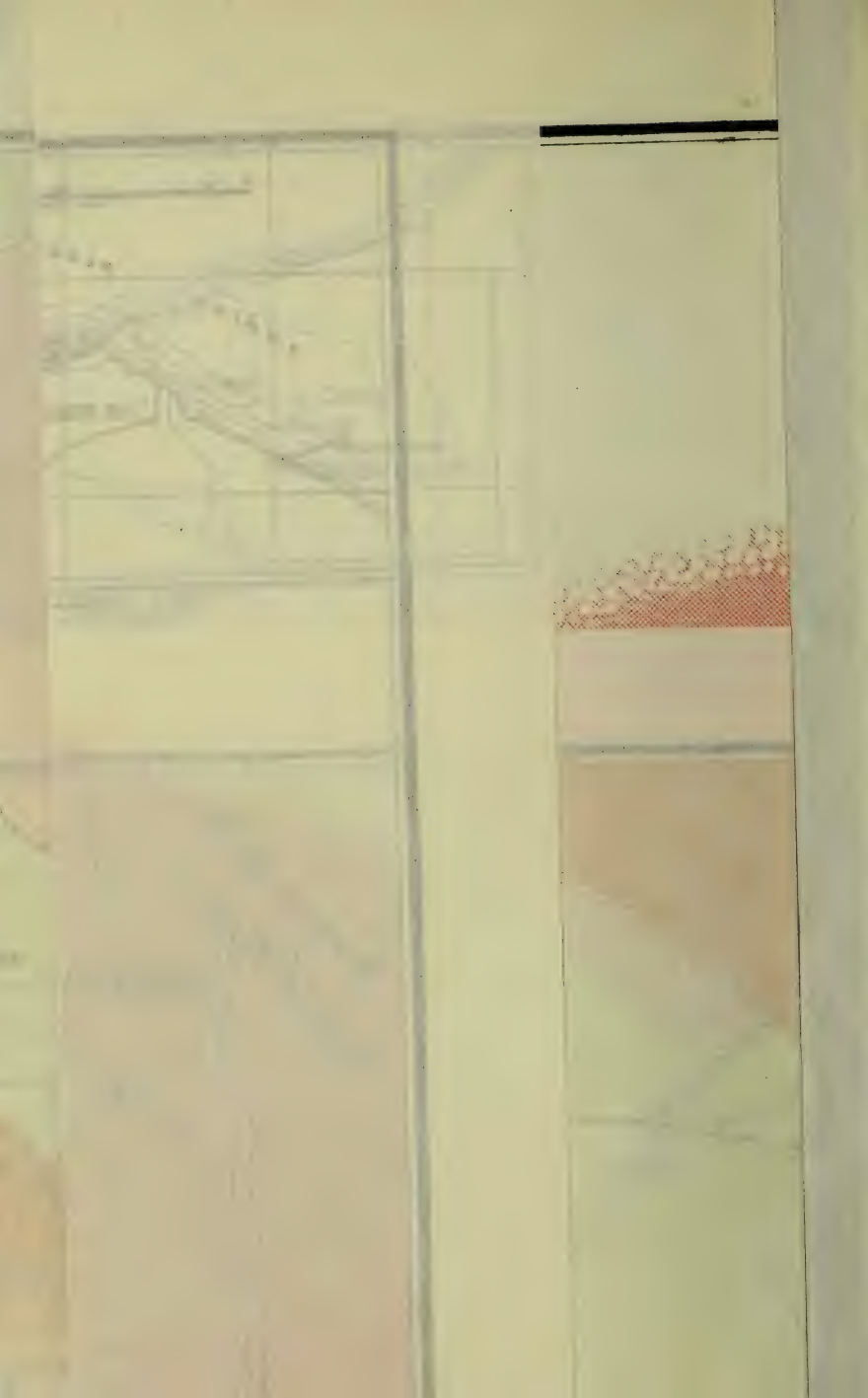
*Synoptical Table showing the Yield of the Bamboo Reefs.*

Name of Reef, &c.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Alpha . . . . .	4·00	8·40	2·10
Bamboo Queen and Reward .	1,390·50	2,436·80	1·75
Bulletin . . . . .	3,329·50	6,362·00	1·91
Mount Prophecy . . . . .	1,658·00	4,072·60	2·45
Nil Desperandum . . . . .	169·00	147·85	·87
Pilbara Goldfields, Ltd. .	2,297·75	3,176·85	1·81
Pilbara Syndicate . . . . .	96·00	119·00	1·23
Premier . . . . .	40·00	88·00	2·20
Tasmanian . . . . .	1,433·00	3,402·40	2·36
Tidal Wave . . . . .	80·00	77·70	1·12
Sundry Claims . . . . .	136·00	438·35	4·17
Total . . . . .	10,633·75	20,329·95	1·91









GENERAL.—From the above descriptions, it appears that there must have been a great deal of work done at Bamboo at one period of its history. It is, however, much to be regretted that no official record appears to have been kept of the state of development and other cognate points of the properties as work proceeded. To overcome this difficulty it is desirable that periodical visits be made by the geological staff and reports be made available to the public from time to time.

### E.—Yandicoogina

(With a Geological Sketch Map of Yandicoogina, Plate V.)

The Yandicoogina centre presents features which link it geologically with Lalla Rookh and Bamboo Creek. The field lies about 35 miles south-east of Marble Bar and 35 miles due south of Bamboo; the relative position of the centre may be seen by a reference to the locality map attached to the earlier pages of the report; its accessibility, however, leaves very much to be desired.

A geological sketch map accompanies this report, and is designed to show, in a general way, the position of the different reefs and their underlie, as well as the area over which the various geological formations extend. This map is based upon the 40-chain lease map L 73, issued by the Department of Mines.

Since the first discovery of the field, Yandicoogina has yielded 5676·50 ozs. of gold, resulting from the milling of 2162·75 tons of ore; these figures give an average of 2·66 ozs. of gold to the ton.

The various formations represented consist of a series of schists and allied rocks, granite, sandstones, and conglomerates, with associated volcanic rocks.

The junction between the sedimentary rocks and the schists is marked, as is the case at Bamboo and Lalla Rookh, by a fault, the general trend of which is north-east and south-west.

With one exception the auriferous reefs are everywhere confined to the area occupied by the schists, which however, as may be seen by an inspection of the geological map, do not occupy a very large area of country.

There are two distinct types of ore deposits on the field, viz., the white quartz reefs, and the laminated quartz (or chert) veins; these latter rise up from the surrounding country in the form of low, often serrated, ridges. The bulk of the gold, however, has been obtained from what may be called the quartz reefs of the normal type. In almost every case which came under observation the reefs of both types were parallel to the planes of foliation (? stratification) of the schists, and may, perhaps, on that account be termed bedded veins.

An impartial observer could not fail to be struck with the backward state of mining, considering the number of years which have elapsed since Yandicoogina was first opened, and the relatively high yield of the reefs as officially recorded. There is not a mine

down 100 feet, and it may be said that the reefs have only been prospected, not mined.

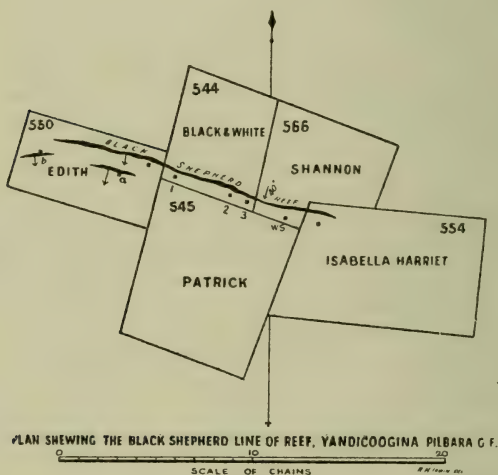
Timber, such as it is, is fairly plentiful within comparatively easy distance, and water is obtainable at a reasonable depth.

All the mines which were open to inspection were visited by me, and full descriptions are given of them in the following pages.

### THE REEFS

What is known as the BLACK SHEPHERD REEF is the most easterly of the groups at present worked at Yandicoogina. The reef itself has been opened up in five different but adjoining leases, viz.: G.M.L. 550, Edith; G.M.L. 544, Black and White; G.M.L. 566, Shannon; G.M.L. 545, Isabella Harriet; and G.M.L. 545, Patrick.

FIG. 14.



The sketch, Fig. 14, shows the relative position of the leases and the shafts, in addition to the reefs outcropping.

The Black Shepherd Reef has a well-defined outcrop of about 1050 feet in length. It has, however, not been followed to any great depth, the deepest workings being under 60 feet below the surface. For purposes of description it will be convenient to deal with the workings on each lease separately, commencing at the western end of the outcrop.

EDITH, G.M.L. 550.—There are two distinct lines of reef on this property; *b* is a small hole which has been put down upon a quartz vein 3 inches in thickness, and which underlies at an angle of 52 degrees to the south. The reef lies along the planes of foliation of the schists in which it is encased. *a* is a similar



quartz reef of from 8 to 10 inches in thickness, lying parallel to the foliation planes of the schists, which in this locality have an average strike of 294 degrees. From the small fragments of quartz which strew the surface, there are good grounds for believing that the stone showing at this spot forms the continuation of the vein exposed in *b*. The main reef has been opened up by means of an open-cut for a distance of about 100 feet north-west along the outcrop, which can be followed along the surface for a distance of 350 feet farther, thus having a total proved length on this property of 450 feet; nothing can be seen, however, giving any clue as to the thickness of the reef. The reef underlies at an angle of about 40 degrees to the south. A main shaft, now disused and inaccessible, had been put down near the north-east angle of the lease with the object of intersecting the reef, but no particulars were obtainable.

During the year 1899 a crushing of 77·60 tons has been recorded as yielding 108·20 ozs. of gold, or at the rate of 1·39 ozs. to the ton.

BLACK AND WHITE, G.M.L. 544.—At the date of my visit the reef had been opened up along the outcrop for a distance of about 100 feet, in addition to which were three shafts, numbers 1, 2, and 3 respectively.

1. A vertical shaft, sunk about 10 or 12 feet back from the outcrop of the main Black Shepherd Reef, has been put down through country rock to a depth of 17 feet 6 inches, at which point the reef was met with. At this point the reef is represented by about 3 inches of quartz. From the foot of the vertical shaft the reef has been followed down on an underlie of 40 degrees to the south for a distance of 19 feet 6 inches. A drive has been put in 10 feet to the east, at a point on the reef 16 feet from the foot of the vertical shaft; at the face the reef is about 6 inches in thickness, though overhead in the drive it averages about 1 foot. A western drive has been put in for a distance of about 15 feet, and exposes a fair-sized body of quartz, some of the faces of which are coated with green carbonate of copper. The stone raised from this shaft is very laminated, gold showing freely in the vicinity of the seams. The quartz contains iron pyrites, copper pyrites, together with a little galena [5409]. Some of the pyrites has weathered out, leaving cubical cavities containing iron oxide, a little gold, and occasionally some free sulphur.
2. A vertical shaft, 20 feet in depth, sunk through schist to the foot wall of the reef. As seen in the workings the reef is about 12 inches in thickness, and is of the same type as that in the adjoining workings (1), of which it is a continuation.

3. A vertical shaft, 10 feet in depth to the point at which it intersects the reef, thence 44 feet down the underlie of the reef. From the foot of the shaft a drive has been put in 15 feet to the west along the reef, which varies from 7 to 8 inches in thickness. The reef occurs along the foliation planes of the schists. The present owners of the property purpose working out the stone from this level to the surface. The stone, which is identical with that above described, prospects very well.

SHANNON, G.M.L. 566 (previously Black Shepherd, G.M.L. 546).—This reef has been worked by what is known as the Water Shaft (W.S.), sunk 38 feet vertically through schist country, at which point the main reef was met with. From the foot of the vertical shaft the reef has been followed on an underlie of 40 feet for a distance of about 46 feet. The reef has been worked from this point for a distance of 140 feet and stoped right out to the surface. There is about 7 or 8 feet of water standing in the shaft.

ISABELLA HARRIET, G.M.L. 554.—The main reef continues on to this property, but the only work done is the sinking of a shaft (now inaccessible) through a fine-grained mica schist, which at the eastern end of the lease gives place to granite of the type prevailing in the district.

*Table showing the Yield of the Black Shepherd Reef.*

Year.	Name of Lease.	Ore Crushed.	Gold therefrom.	Rate per Ton.	Total Ore Crushed.	Total Gold therefrom.	Average Rate per Ton.
		Tons.	Ozs.	Ozs.	Tons.	Ozs.	Ozs.
1899	Edith, G.M.L. 550	77·60	108·20	1·39	77·60	108·20	1·39
1898	Black and White, G.M.L. 554	17·75	48·25	2·71			
1899	„ „	157·70	1396·62	2·51	192·45	487·37	2·53
1900	„ „	17·00	42·50	2·50			
1898	Black Shepherd, G.M.L. 546	16·30	101·40	6·22			
1899	„ „ subsequently	117·20	732·82	6·25	148·00	848·72	5·73
1900	Shannon, G.M.L. 566	14·50	14·50	1·00			
1899	Patrick, G.M.L. 545	34·00	144·80	4·26			
1900	„ „	82·50	245·50	2·97			
1901	„ „	76·00	120·70	1·58	215·00	572·00	2·66
1903	„ „	22·50	61·00	2·71			
		Total	.	.	633·08	2,016·29	3·18

<sup>1</sup> Includes 140·27 ozs. of dollied and specimens.

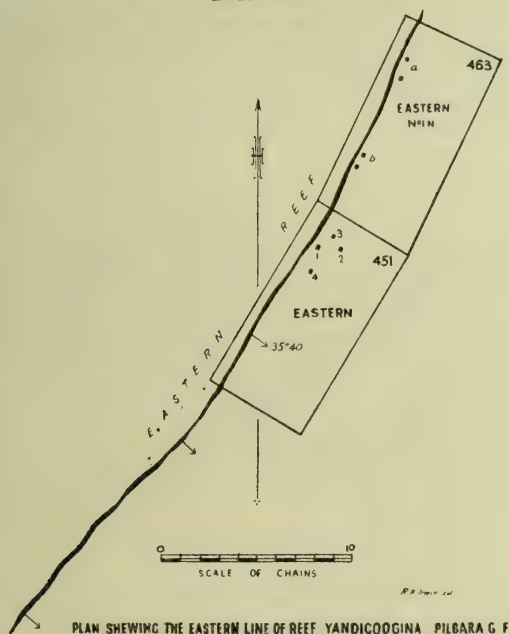
PATRICK, G.M.L. 545.—No work at present being carried out. Considering the returns from the Black Shepherd Reef, it is a pity that efforts have not been made, by either boring or shaft sinking, to intersect the reef at a depth in the Patrick Lease.

From the above figures it appears that the crushings recorded since 1898 show that the average yield of the Black Shepherd Reef has been at the rate of over 3 ozs. per ton.

#### EASTERN REEF.

The Eastern Reef lies about 60 chains to the north-west of the

FIG. 15.



Black Shepherd, outcrops for about 2600 feet and has been opened up in eight or nine different localities.

The sketch plan shows the relative position of the leases, the workings, and the outcrop of the reef, so far as it can be followed on the surface.

The reef is worked in two leases, viz., The Eastern G.M.L. 451, and the Eastern No. 1, G.M.L. 463. The reef has a general strike of N. 30 E., and an underlie to the south-east at angles varying from 35 to 40 degrees.

EASTERN No. 1, G.M.L. 463.—The eastern reef enters the lease on the north-eastern boundary and continues without interrup-

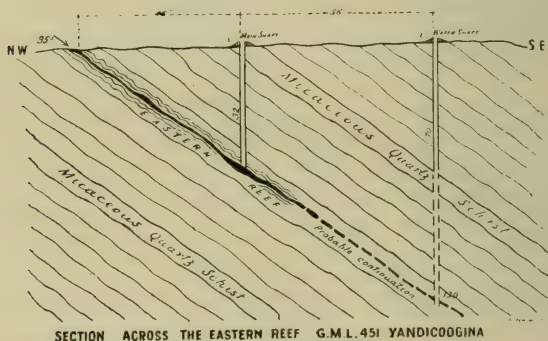


tion across the whole length of the lease. The reef has been opened up in two separate localities (*a*) and (*b*). At (*a*) are two shafts, inaccessible at the date of my visit, sunk to the south-east of the reef, which at this point had been opened up for about 42 feet along the outcrop. At the southern end of the trench the reef is encased in the foliation planes of the schist, which forms the staple matrix of the auriferous reefs in this neighbourhood.

There is a fair quantity of stone at grass awaiting crushing. The same reef can be followed across the lease to (*b*), near the southern boundary of the property. The reef at this point has been followed for a distance of 35 feet along the outcrop, and two shafts, now quite inaccessible, were put down with the object of intersecting it at a depth. These shafts, the deepest of which is 29 feet, were sunk through decomposing micaceous schists. A crushing of 23 tons, in the year 1898, yielded 28.75 ozs. of gold, or at the rate of 1.25 ozs. per ton.

EASTERN, G.M.L. 451.—The reef enters this property at the north-east boundary, and traverses the lease from end to end

FIG. 16.



SECTION ACROSS THE EASTERN REEF G.M.L. 451 YANDICOGINA

without any interruption. Four shafts have been used to work the reef, viz., 1, 2, 3, and 4.

The Main Shaft (1) has been put down 46 feet, at which point the reef was intersected, and was found to be 5 feet in thickness. From the foot of the shaft, the reef has been followed down for a distance of 35 feet on the underlie, as shown in the section, Fig. 16.

A drive 40 feet in length has been put in along the reef to the northwards from the foot of the underlie, there is, however, only an inch or two of quartz showing in the face. Southwards from the underlie the drive has been continued for about 20 feet, and at the face of the drive the reef measures 2 feet 9 inches in thickness. Shaft (2), better known as the Water Shaft, has been sunk to a depth of 70 feet through a micaceous quartz schist [5411].

At the date of my visit there was 11 feet of water standing in the shaft, and I was informed that while the shaft was being sunk, water at the rate of from 600 to 1100 gallons per hour flowed in. It is contemplated continuing this shaft, when proper pumping appliances are available, with the object of striking the Eastern Reef, which should be met with at 110 to 130 feet.

Shaft (3) is situated near the north-west angle of the lease, and has been carried down to a depth of 22 feet vertically. The reef at the foot of the shaft is 3 feet 2 inches in thickness, and is of the usual type. The reef has been worked out from this level to the surface and is said to have yielded good returns. Shaft (4), which was inaccessible at the date of my visit, had been carried down to a vertical depth of 40 feet, and showed about 3 feet of quartz, which, however, is said to have been unpayable.

The quartz [5410] contains a little iron pyrites, galena, together with small quantities of green and blue carbonates of copper. A good deal of free gold is showing in the stone at grass, of which there is estimated to be about 200 tons. There has been no crushing for about 2 years. From the fact that some of the stone in the eastern reef is slickensided it would seem that considerable movement has taken place since the formation of the reef, an observation which is confirmed by the occurrence of violently contorted and puckered "formation" (crushed rock) between the walls. Work has hardly been carried on sufficiently far for any observations as to the trend of the ore chutes to be definitely made out. Between the years 1898 and 1903, there have been crushed from this lease 665·85 tons of quartz, recorded as yielding 777·55 ozs. of gold, thus averaging 1·17 ozs. to the ton.

The Eastern Reef can be followed for a distance of 1100 feet along the outcrop, from the south-eastern boundary of G.M.L. 451.

The following table shows the yield of the Eastern Reef, as shown by official data:—

*Table showing the Yield of the Eastern Reef.*

Year.	Name of Lease.	Ore Crushed.	Gold therefrom.	Rate per Ton.	Total Ore Crushed.	Total Gold therefrom.	Average Rate per Ton.
		Tons.	Ozs.	Ozs.	Tons.	Ozs.	Ozs.
1898	Eastern No. 1, G.M.L. 463	23·00	28·75	1·25	23·00	28·75	1·25
1898	Eastern, G.M.L. 451	114·00	154·40	1·35			
1899	" . . .	359·85	398·05	1·10			
1900	" . . .	22·50	31·75	1·41			
1901	" . . .	35·50	51·60	1·45			
1902	" . . .	Nil.	Nil.	Nil.			
1903	" . . .	111·00	113·00	1·02	642·85	748·80	1·16
	Total . .	...	...	...	665·85	777·55	1·17

## LADY ADELAIDE REEF.

The Lady Adelaide Reef lies about 60 chains south-west from the Eastern Reef, and the outcrop is parallel thereto. It is possible, however, that the two are one and the same reef, although the quartz [5413] differs somewhat from that of the Eastern. The reef can be followed along the surface for about 2000 feet.

LADY ADELAIDE, G.M.L. 49.—No work was going on at the date of my visit. A main shaft had been put down to a vertical depth of 60 feet, and is said to have passed through the reef at 15 feet. A drive about 70 feet in length has been put in in a south-easterly direction from the foot of the shaft, and another of 20 feet to the north-west; both, however, are now full of water, which reaches to a height of 9 feet from the bottom of the shaft.

The Lady Adelaide Reef has been opened up along the surface for a considerable distance northwards, but very little work appears to have been done, as is borne out by the records of crushing shown in the table.

*Table showing the Yield of the Lady Adelaide Reef.*

Year.	Name of Lease.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1898	Lady Adelaide No. 1, G.M.L. 562	Tons. 35·25	Ozs. 62·80	Ozs. 1·78
1899	„ „	20·00	22·50	1·12
1900	„ „	Nil		
1901	„ „		3·00	·50
	Total . .	61·25	88·30	1·44

## UNCLE TOM REEF.

The Uncle Tom Reef traverses three properties: Cyclone, G.M.L. 386; Uncle Tom, G.M.L. 250; and Uncle Tom West, G.M.L. 461.

CYCLONE, G.M.L. 386.—A fairly well-defined quartz reef, having an average bearing of 25 degrees 30 minutes, has been opened up along its outcrop for about 130 feet. The workings are inaccessible, hence nothing could be seen. There do not appear to have been any crushings recorded from this property. This reef can be followed with scarcely any interruption south-westerly into the adjoining lease—the Uncle Tom.

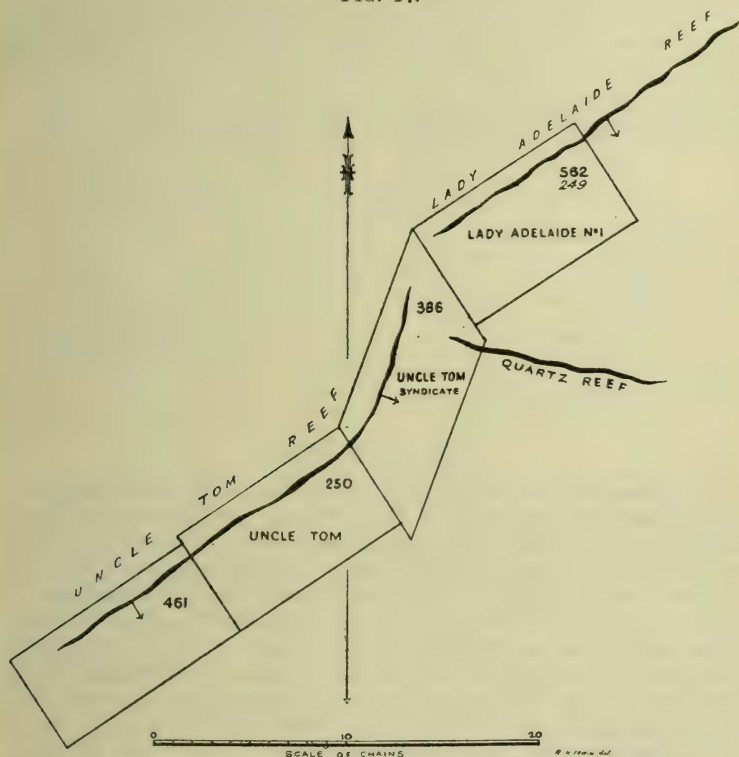
UNCLE TOM, G.M.L. 250.—A good strong reef, forming the summit of a fairly conspicuous ridge, outcrops on a bearing of 63 degrees, and has been, so far as may be judged by the condition



of the surface, extensively worked. The workings, however, are inaccessible, hence nothing can be seen as to the behaviour of the reef underground. So far as may be seen by the material at grass, the reef occurs in schist country.

The following plan shows the relative positions of the Lady Adelaide and the Uncle Tom Reefs:—

FIG. 17.



PLAN SHEWING THE POSITION OF THE LADY ADELAIDE AND UNCLE TOM REEFS YANDICOOGINA.

A parallel reef outcrops on a bearing of 56 degrees, and is situated 33 feet north of this main reef. This reef has been worked to some extent. A shaft, 62 feet from the north-west angle of the lease, on a bearing of 276 degrees, has been carried down 29 feet vertically. The reef measures 3 feet between the walls. The quartz [5415] from the reef contains large quantities of massive iron pyrites, often in pieces of large size, a little galena, and, in much smaller proportions, zinc blende.

An east and west reef, which may have some connection with the main quartz reef, enters the lease at the north-east

angle of the ground, and can be followed eastwards for about 900 feet.

The following table gives the total gold yield of the Uncle Tom line of reef:—

*Table showing the Yield of the Uncle Tom Reef.*

Year.	Name of Lease.	Ore Crushed.	Gold therefrom.	Rate per Ton.	Total Ore Crushed.	Total Gold therefrom.	Average Rate per Ton.
		Tons.	Ozs.	Ozs.	Tons.	Ozs.	Ozs.
1898	Uncle Tom, G.M.L. 494	100·00	440·00	4·40			
1899	" "	46·50	218·41	4·69			
1900	" "	130·70	251·25	1·92			
1901	" "	27·00	76·75	2·84	382·20	1,299·71	3·24
1903	" "	78·00	313·30				
1899	Uncle Tom West, G.M.L. 461	83·85	146·75	1·75			
1900	" "	15·00	24·00	1·60			
1901	" "	47·00	82·75	1·76	145·85	253·50	1·73
	Total . .	...	...	...	528·05	1553·21	2·74

#### AUNT SALLY REEF.

A quartz reef, from which two small crushings have been recorded, has been worked on G.M.L. 495, but being abandoned and at the present time wholly inaccessible, no description of either the nature of the reef or its behaviour underground can be given. It is conceivable that the Aunt Sally Reef is the continuation of that east and west reef which enters the Uncle Tom, G.M.L. 386, at its north-west angle. If this be so, then it appears probable that a certain amount of longitudinal movement had taken place along the line of the Uncle Tom and Lady Adelaide Reefs, and has had the effect of dislocating the Aunt Sally Reef. The yield of this reef is shown in the following return:—

*Table showing the Yield of the Aunt Sally Reef.*

Year.	Name of Lease.	Ore Crushed.	Gold therefrom.	Rate per Ton.
		Tons.	Ozs.	Ozs.
1898	Aunt Sally, G.M.L. 495 . .	13·50	12·75	·94
1899	" " . .	13·50	8·25	·61
	Total . .	27·00	21·00	·78

## TRILBY REEF.

Another reef, the Trilby, which may represent a continuation of the Uncle Tom Reef, has been worked in the G.M.L. 396, on the western bank of one of the important tributaries of Yandicoogina Creek. The reef occurs in the belt of schist, which traverses the whole length of the productive area of the field. The property was abandoned, and the workings inaccessible, hence no details as to the character and dimensions of the reef were obtainable. As may be seen by the table attached, there have been two small crushings recorded, one averaging two and three-quarter ounces of gold to the ton, and the other nearly three and a half ounces.

*Table showing the Yield of the Trilby Reef.*

Year.	Name of Lease.	Ore Crushed.	Gold therefrom.	Rate per Ton.
		Tons.	Ozs.	Ozs.
1898	Trilby, G.M.L. 396 . .	35·25	122·80	3 48
1899	„ „ . .	30·75	84·70	2 75
	Total . .	66·00	207·50	3·14

## INVINCIBLE REEF.

The Invincible Reef lies on the western bank of Yandicoogina Creek, about a mile and a half south-west of the Uncle Tom line. The reef has been worked in two adjoining properties of six acres each, viz., the Invincible, G.M.L. 557, and G.M.L. 561. The main reef has an average strike of 281 degrees, and underlies to the south at angles varying from 25 to 30 degrees, and is enclosed in schist of the usual type. About 20 feet to the south is a parallel, though very thin, vein of laminated jasper (chert?) of the type which forms such a conspicuous feature in many of the other gold-fields of the State. The quartz [5414] of the main Invincible Reef is a grey glassy variety, apparently entirely devoid of any accessory minerals other than gold. So far as may be seen, the reef is about 1 foot in thickness.

There are three shafts on G.M.L. 557, but, beyond two men engaged in dry-blowing, no work of any description was being carried out. The main shaft is said to have been carried down 39 feet vertically (at which depth the reef was met with), and continued some distance farther on the underlie of the reef. Water is standing in the underlie, which prevents anything being seen.

The Invincible Reef has a record of 52·31 ozs. to the ton, obtained from a crushing of 13·40 tons of quartz, which yielded

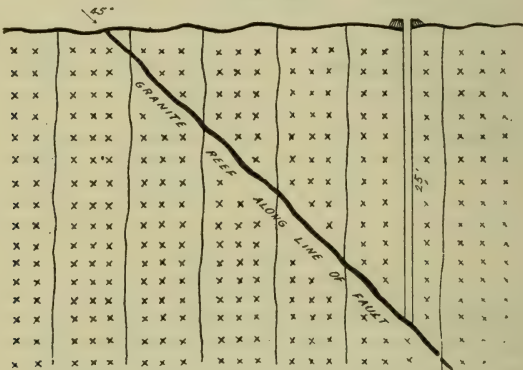


701 ozs. of gold. This crushing, which took place in 1899, is the only one recorded from the property.

GRANITE REEF.

What is known as the Granite Reef is situated some miles due north of the Black Shepherd, and, as may be inferred from its name, occurs in the granite area, which occupies such an extensive tract of country to the north of Yandicoogina. The reef, which, so far as can at present be seen, is only from 6 to 8 inches in thickness, has an average strike of 100 degrees, and an underlie of from 40 to 45 degrees to the north. Operations have been confined to sinking a vertical shaft, through granite, to the depth of 25 feet, and taking out the whole of the stone from this level to the surface.

FIG. 18.



SECTION ACROSS THE GRANITE REEF G M L 586 YANDICOOCINA

The country rock, as is shown (Fig. 18), is traversed by vertical joints.

Some little distance to the west of this is another quartz reef, 1 foot 3 inches in thickness, underlying to the south at an angle of 31 degrees. Very little work has been done upon this reef. The quartz [5412] contains galena arranged in bands through the stone, and a little zinc blende in addition to free gold.

Table showing the Yield of the Granite Reef.

Year.	Name of Lease.	Ore Crushed.	Gold therefrom.	Rate per Ton.
		Tons.	Ozs.	Ozs.
1900	Granite, G.M.L. 586	9·00	40·50	4·50
1901	„ „	26·00	52·00	2·00
	Total	35·00	92·50	2·64

In addition to the above-mentioned reefs, there are one or two others which are at present abandoned and to which access is not obtainable, hence any description thereof is impossible.

The following synoptical table gives the total gold yield of Yandicoogina obtained from official statistics up to the end of 1903:—

*Synoptical Table showing the Yield of the Yandicoogina Reefs.*

Name of Lease.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Aunt Sally . . . . .	27·00	21·00	·78
Black Shepherd . . . . .	633·05	2,016·29	3·18
Eastern . . . . .	665·85	777·55	1·17
Granite . . . . .	35·00	92·50	2·64
Harp of Erin . . . . .	22·50	11·55	·51
Invincible . . . . .	13·40	701·00	52·31
Jupiter . . . . .	113·50	586·70	5·17
Lady Adelaide . . . . .	61·25	88·30	1·44
Lone Hand . . . . .	16·00	23·30	1·45
Trilby . . . . .	66·00	207·50	3·14
Uncle Tom . . . . .	528·05 <sup>1</sup>	1,553·21	2·94
Zingari . . . . .	8·40	6·80	·80
Sundry Claims . . . . .	84·75	385·00 <sup>1</sup>	4·54
Total . . . . .	2,274·75	6,470·70	2·62

Adding to this the 325 ozs. obtained by cyaniding 700 tons of tailings accumulated at the Lady Adelaide Battery and from the reefs it is impossible to specify, it appears that 6795·70 ozs. of gold from 2274·75 tons of ore has been obtained from the mining centre of Yandicoogina; and, so far as operations have at present gone, the average yield per ton of ore has been 2·98 ozs.

### F.—Mount Elsie

The Mount Elsie Diggings are situated about 30 miles to the east of Yandicoogina, on the head-waters of Elsie Creek, one of the tributaries of the De Grey (Nullagine) River. The mountain from which the district takes its name rises to a considerable altitude above the general level of the surrounding country, and forms a very conspicuous feature in the landscape, visible for many miles in all directions. Mount Elsie itself is formed of schistose rocks, intersected by numerous laminated, iron-stained quartz reefs, with thin quartz leaders ramifying in all directions. These schists are sandwiched, as it were, between two belts of limestone-like weathering schist of the type common to those portions of the Pilbara Goldfield so far examined, as is seen in the geological section,

<sup>1</sup> Includes 234·50 ozs. dollied.

Fig. 7. The southern slopes of the hill are drained by a deep gully and its tributaries, and at the date of my visit two men were engaged in dry-blowing, with fairly successful results. The detrital gold in the creek is evidently of distinctly local origin, and owes its presence to the disintegration of the numerous quartz leaders by which the hill is traversed. What may be called the Mount Elsie belt is continuous for some miles to the south-east, and several well marked summits rise from different portions of the belt. One of the most prominent of these rises to a height of about 380 feet by aneroid above the camp at the base of Mount Elsie. This hill forms the continuation of what may be called the Mount Elsie Group of Reefs, which outcrop with more or less interruption along the summit and the flanks of the tortuous ridge, of which the hill forms a part. The hill itself is formed of decomposing greenstone, traversed by a network of somewhat quartzose ironstone veins. Several old workings and dry-blown patches attest the fact that the district must have been the scene of more or less desultory prospecting at one period of its history.

Another summit, about a mile to the north-east, is formed of what appears to be decomposed massive greenstone, intersected by veins of quartz and ironstone.

No mining operations of any kind were going on at the date of my visit to Mount Elsie, and, judging by the condition of affairs, very little had gone on for some considerable time.

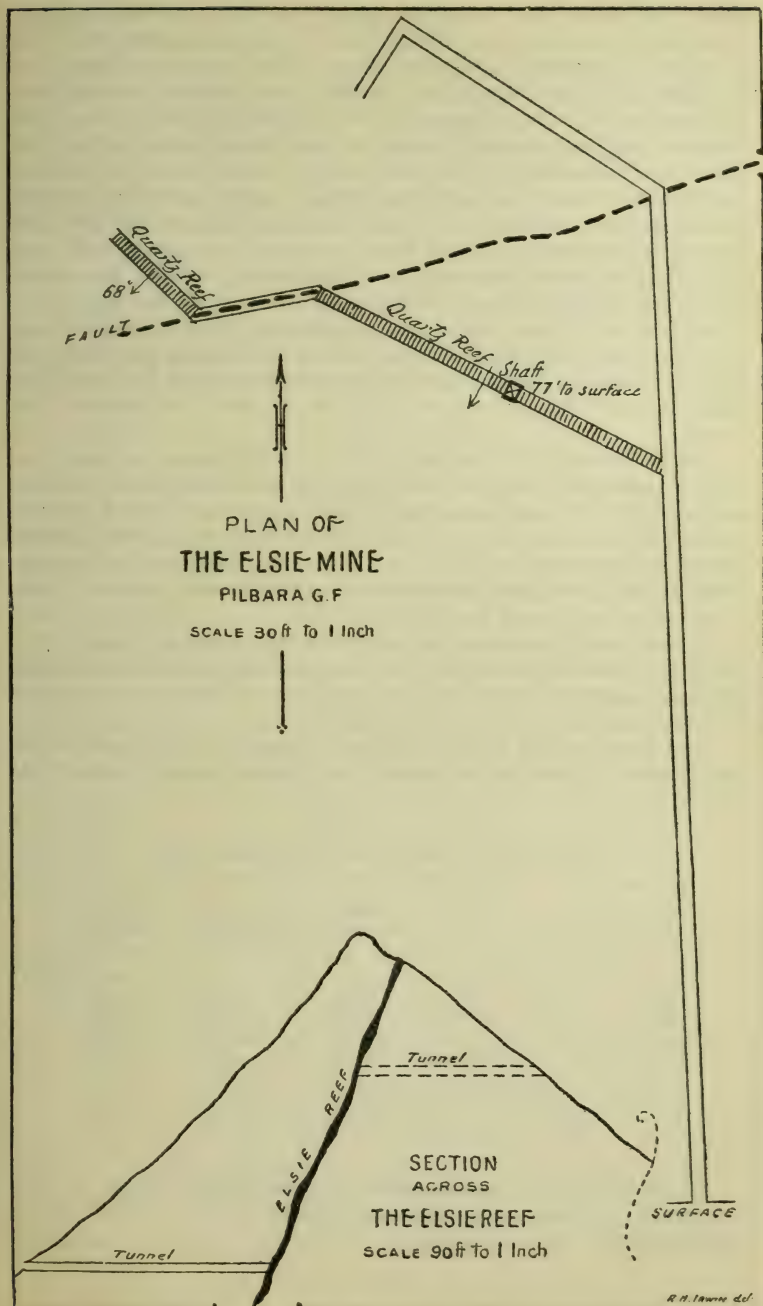
ELSIE, G.M.L. 86.—The only place at which any serious attempt at mining had been carried out was at the Elsie mine, which is situated at the foot of the hill from which the locality derives its name. A plan and section of the workings of this mine is shown in Fig. 19.

The Mount Elsie Mine is the same as that shown on the maps of the district as Duncan and Sullivan's Gold Mine.

The outcrop of the Elsie Reef forms the summit of a high ridge, which extends for a considerable distance to the west. The reef has been worked from the outcrop down to a point some 76 to 80 feet vertically below it, on an underlay of about 68 to 70 degrees. The reef has been worked along the outcrop for 104 feet from the mouth of the shaft. A crosscut has been put in northwards from the base of the hill at a few feet above the level of the creek. This crosscut, which had been carried through greenstone, intersected the Elsie Reef at a point 150 feet from the mouth; here, however, it is only an inch or two in thickness. As measured in the drive along the reef, the strike is 298 degrees. Twenty-six feet from the crosscut is the underlie shaft connected with the surface. At the foot of the underlie shaft the "reef" is made up as follows: Quartz, 1 foot on the footwall, and quartz 4 inches on the hanging wall, separated by about 12 inches of formation. A good deal of work had evidently been done below the level of the drive at the shaft, but very little could be seen owing to its inaccessibility. Thirty-four feet north-west from the shaft a cross-



FIG. 19.



course (? fault) crosses the reef on a bearing of 260 degrees, and shifts the main reef westward about 20 feet; at this point it resumes its normal course (315), and has been opened out for a distance of 18 feet. The face of the drive, however, shows but 2 inches of quartz, underlying to the south-west at an angle of 68 degrees. The crosscourse (? fault) carries a little quartz; the crosscut has been carried about 40 feet north from the point at which it is crossed by the main reef, to what in all probability marks the extension of the crosscourse (? fault). Owing, however, to the similar nature of the rock throughout the whole length of the tunnel, rendering a fault, unless marked by a quartz reef, very difficult of detection, this cannot be definitely proved. The crosscut (?) has been continued for a farther distance of 49 feet along a bearing of 302 degrees, or roughly parallel to the main quartz reef, but, so far as may be seen, without opening up any fresh ore body. From the face of the tunnel the country to the south has been explored for a distance of 16 or 17 feet, but without any success.

Some distance farther west and at a very much higher level on the northern flank of the ridge, a tunnel, as shown in the section, Fig. 19, has been put in on a bearing of 221 degrees through greenstone for a distance of 94 feet to the reef, which proved to be 12 inches thick. Free gold was showing in the stone lying at the mouth of the tunnel, and which had obviously been obtained from the reef itself.

When the Elsie mine was at work the ore was crushed at a Tremaine Mill erected at the base of the hill; water for crushing purposes was obtained from a well put down in greenstone country in close proximity.

The yield of the Elsie Reef may be seen by an inspection of the figures in the table, which have been taken from official sources:—

*Table showing the Yield of the Elsie Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1899 . . . . .	14·25	268·45	18·83
1900 . . . . .	28·00	204·00	7·28
1901 . . . . .	230·00	519·77	2·26
1902 . . . . .	136·00	421·60	3·10
Total . . . . .	408·25	1,413·82	3·46

In addition to this, the official figures disclose that in 1901 20 tons of ore from sundry claims yielded 17·90 ozs. of gold, or at the rate of ·89 ozs. to the ton.

### G.—Boodalyerri

The almost abandoned workings at Boodalyerri lie about six miles to the east of Mount Elsie, and occur in granite country, which occupies an extensive area in the vicinity. The workings, though in granite country, are situated not far from the boundary of the basic schists into which the granite is clearly seen to be intrusive. In the vicinity of the schists, the granite has a rude foliation, but whether this is of the same age as that which affects the schists cannot be satisfactorily made out. The greenstone schists are associated with beds of micaceous schists.

A series of photographs, showing the intrusive nature of the granite, were taken, as well as the workings at Martin's Mine; but, owing to difficulties of temperature, transport, &c., none of the negatives, on being developed, proved fit for reproduction.

#### GOLDEN GRANITE G.M.L. 601.

The Golden Granite Mine at Boodalyerri, worked by Mr. Martin, lies about 6 miles to the east of Mount Elsie, and is situated in the granite area which occupies such an extensive tract of country in this portion of the district. The deposit, so far as could be seen at the date the district was visited, consists, as shown in the generalised section, Fig. 20, of an irregular network of small quartz leaders (many of them less than a quarter of an inch in thickness), occurring in close proximity to a greenstone dyke. Mining operations have been carried out along a joint striking N. 40 W., and underlying at 65 degrees to the west. For some distance from either wall of the joint, which carries a thin vein of quartz, the granite has been altered into a greenish yellow rock [5395], the composition of which, as determined by Mr. E. S. Simpson, is shown by the figures in the table on page 7. The zone of decomposition has no defined boundaries, but passes almost insensibly into the normal granite of the neighbourhood. The decomposed rock contains small quantities of iron pyrites.

A vertical shaft, 32 feet distant from the outcrop, intersects the greenstone dyke at 20 feet from the ground level, at which point it is 4 feet in thickness.

About 500 ozs. of alluvial gold are stated to have been obtained from the gully adjoining the reef, to the disintegration of which, the origin of the detrital gold may be ascribed. The official returns, however, show only 160 ozs. of alluvial gold from this centre; it is, however, probable that a good deal of the gold won has not been officially reported, or else it has been included in the returns from the "district generally."

Another rich leader about 197 feet north and 30 feet west from the main shaft has been worked, and about 16 tons of stone raised, which are said to have yielded 100 ozs. of gold. This leader, which

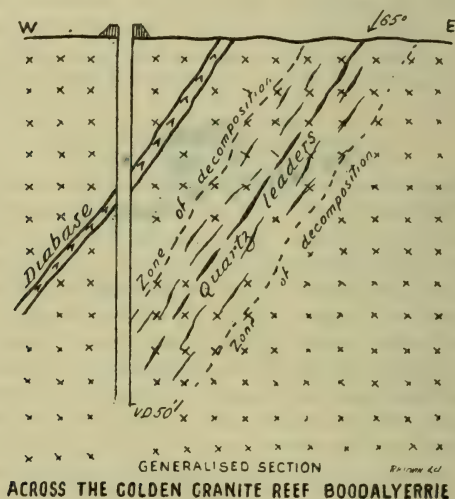


occurs in a similar decomposed granite country, has been followed to a depth of 50 feet below the surface, at which point it cut out. The general strike of the leader practically coincides with that previously described.

The stone at the Golden Granite was crushed on the spot by a small 3-head mill driven by a windmill; and another smaller one was utilised for raising water from the dam to the battery tanks.

G.M.L. 617. —Some distance to the north-east of the Golden Granite Reef lies what was known as Bateman and White's

FIG. 20.



Reward, at one time held as G.M.L. 617. The property, however, has been abandoned. So far as could be seen, the reef bears north 72 degrees west, and underlies to the south at a very high angle. About 6 tons of quartz from this vein are said to have yielded 93·50 ozs. of gold. The vein upon which operations have been carried out lies 150 feet distant from a very large quartz reef, which has an average strike of 162 degrees. The reward lease lies amid a network of reef and leaders, lying roughly parallel to one another.

From what is known as the Granite Proprietary G.M.L. 598, there have been obtained 50 ozs. of dollied and specimen gold, whilst from sundry claims in the vicinity there have been officially reported in 1900 160 ozs. of gold, thus bringing the total yield of this small mining centre up to 1130·55 ozs.

The records show that the Golden Granite lease has produced the gold showing in the following table:—







*Table showing the Yield of the Golden Granite Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1901	.	.	.	.	14.25	<sup>1</sup> 250.00	17.54
1902	.	.	.	.	18.00	<sup>2</sup> 159.05	8.83
1903	.	.	.	.	74.00	418.00	5.65
Total					106.25	827.05	7.78

**H.—Mosquito, Sandy, and Middle Creek Districts***(With a Geological Sketch Map, Plate VI.)*

**MOSQUITO CREEK.**—The reefing centre of Mosquito Creek lies about 24 miles due east of Nullagine, upon the head waters of the Nullagine River, and, according to the official statistics, has been responsible for 4715.58 ozs. of the gold from the Pilbara Field, as reported at the close of 1903.

The staple formation in the district consists of schistose rocks, which are either vertical, or, at any rate, inclined at high angles. These schists are associated with sedimentary rocks (grits, shales, and fine conglomerates), from which, however, they could not be satisfactorily separated. These sedimentary beds appear, *primâ facie*, to belong to an older series than those shown by the symbol **M** on the geological maps attached to the report, and inferentially assumed to be Cambrian(?). These beds of doubtful geological age which form the matrices of the auriferous reefs, have been invaded by granite rocks, a conspicuous boss of which [5425] forms an important feature at the township of Mosquito. The position of this is shown on the geological sketch map. This granite boss has a length of about 90, and a maximum width of about 40 chains, and rises to a considerable height above the level of the surrounding country, and makes a prominent feature in the landscape, and is visible from a distance of several miles.

The time at my disposal in the district was such as permitted questions of economic geology only being dealt with, hence there was little opportunity of investigating purely stratigraphical details, to the solution of which this district would afford ample important evidence.

**THE REEFS**

The following is such a description of the various mining properties as were open to inspection at the date of my visit; the location of many of the properties will be found on the geo-

<sup>1</sup> Includes 74.00 ozs. of dollied and specimens.<sup>2</sup> Includes 25.00 ozs. of dollied and specimens.

logical sketch map of Mosquito Creek, and others on the 40 chain Lithograph, L 77, issued by the Department of Mines; the individual claims, however, not being surveyed, do not appear on any map.

For convenience of description the properties are described in geographical order, commencing at the easternmost end of the field.

NICHOL'S REWARD, R.C. 74 L.—A small property comprising a little over 11 acres. Three shafts have been put down near the north-east angle of the lease. The northernmost shaft had been put down to a vertical depth of 100 feet, but at the date of my visit was inaccessible below a depth of 40 feet. The reef is very bunchy and irregular, but attains a thickness of from 6 to 8 feet in places. So far as may be seen in the workings, the reef occurs along a shear plane in the schists. A few feet to the south-west of this, two shafts have been sunk upon a quartz reef, which has an average strike of 89 degrees and a slight underlay to the north. The easternmost of the two shafts is stated to have been carried down to a vertical depth of 70 feet, but was inaccessible below 50 feet. A good strong reef, 10 feet in thickness, has been worked, but it appears to have gradually petered out, and at the foot of the shaft, it is said to be only an inch or two in thickness. The workings have been connected with another vertical shaft a few feet to the west. The reef is of the same nature and character as that in the northern shaft. So far as may be judged by the surface, there is every probability of the reef having a considerable horizontal extent, though everything points to the fact that it would be expected to be extremely irregular in its thickness.

The following table shows the crushings from this property, so far as may be gathered from the official statistics :—

*Table showing the Yield of Nicol's Reward Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1900	.	.	.	.	125·15	232·05	1·85
1901	.	.	.	.	127·00	167·12	1·31
1902	.	.	.	.	162·00	190·60	1·17
1903	.	.	.	.	36·00	59·75	1·66
Total . . . .					450·15	649·52	1·44

The fairly consistent returns from this property would seem to me to warrant rather more vigorous and systematic prospecting than has hitherto taken place.

G.M.L. 131 L.—A 12-acre lease adjoining the Reward Claim on the west. Very little work of any kind had been done on the lease. A ferruginous vertical quartz reef of about 2 feet in thickness enters the lease on its western boundary close to the

south-west corner of the Federal, G.M.L. 97. This reef trends generally east and west, and appears to be of some horizontal extent. No work appears to have been done upon it.

FEDERAL, G.M.L. 97 L. (109 L.).—A 6-acre lease between the Parnell and that previously described. A good deal of more or less desultory work has been carried out upon the lease.

Near the centre of the property, a water-shaft is being sunk under an agreement with the Government.<sup>1</sup> Near the north-west angle of the lease is another shaft 44 feet in depth, on a reef striking generally east and west, but not much work has been done upon it. Farther to the north on the lease some desultory work has been done upon a parallel reef.

According to the official returns, the two crushings recorded from this reef have averaged about an ounce and a quarter to the ton.

The following table gives the crushings from this lease :—

*Table showing the Yield of the Federal Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1901	.	.	.	.	7·00	12·75	1·82
1902	.	.	.	.	41·00	46·45	1·13
Total . . .					48·00	59·20	1·23

PARNELL, G.M.L. 95.—A 12-acre lease, owned by the Bell Exploration Company, upon which three shafts have been sunk, and a 10-head battery, to which it is proposed to add a cyanide plant, erected.

The most easterly shaft has been carried down to a depth of 87 feet upon a quartz reef underlying to the north. At the foot of the shaft the reef is about 3 feet thick, and at one place higher up it reaches as much as 5 feet. The hanging wall of the reef is a kaolinic decomposed rock, which has every appearance of being one of the sandy beds forming the sedimentary series. No driving has been done on the reef. Some distance to the south-west of this is another shaft, said to have been carried down to a depth of 80 feet, but at the date of my visit was inaccessible below about 30 feet from the surface. The reef is continuous with that occurring in the shaft previously mentioned. The reef is about 3 or 4 feet in thickness. Not much work, however, appears to have been done upon it. The main or water shaft has been sunk to a depth of about 160 feet, and two crosscuts put in to the southward at 100 and 160 feet respectively. The uppermost crosscut has been carried 40 feet, and the lower one about 20 feet, through a

<sup>1</sup> On the 7th of March, the District Engineer in charge of the Mines' Water Supply, reports that the shaft was down 110 feet, without any sign of water being obtained.—A.G.M.



decomposed sandy rock, which has every appearance of being a sandstone or grit. The reef, which, so far as has been opened up, is small and irregular, occurs at the junction of the sandstone (?) and a very much harder and fine-grained rock, the nature of which cannot be satisfactorily determined, as the bed has only just been pierced.

A supply of water, said to be sufficient to keep the 10-head mill running eight hours, is drawn from this shaft, but after a long period of dry weather a material difference in the yield is said to be noticeable.

According to the official figures, it appears that the yield of the stone crushed from this lease has been just over an ounce, and, as seen by the following table, only 357 tons of ore has been raised and crushed in three years:—

*Table showing the Yield of the Parnell Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1900	.	.	.	.	59·00	79·30	1·34
1901	.	.	.	.	143·35	184·60	1·28
1903	.	.	.	.	155·00	120·50	·77
Total . . .					357·35	384·40	1·07

PARNELL No. 1 WEST, G.M.L. 96 L.—This is a 6-acre lease adjoining the one previously described. The easternmost shaft has been sunk to a vertical depth of 56 feet upon a reef which there is every reason to believe is the continuation of the one met with in the 87-feet shaft on the Parnell. As seen on the surface near the shaft the reef varies from 3 to 4 feet in thickness, whilst at the foot of the shaft it has dwindled to 12 inches. The hanging wall side of the reef is a squeezed or sheared slate. Another shaft, on what may be a parallel reef, has been put down near the north-western corner of the lease. There was little to be seen of it. The only crushing from the Parnell West took place in 1901, when 36·75 tons of stone yielded 24·50 ozs. of gold, or at the rate of 0·66 ozs. to the ton.

PARNELL NORTH, G.M.L. 146 (formerly G.M.L. 102).—A 6-acre lease adjoining the Parnell on the north. A main shaft, 90 feet in vertical depth, has been sunk on a north-west and south-east reef said to be continuous with one occurring in the Federal lease, referred to above. The maximum thickness of the reef exposed is 5 feet, although the average varies between 18 inches and 2 feet. There is, however, very little to be seen of the reef owing to the condition of the workings. The stone [5427] shows free gold in places. A little work has been done on an east and west reef,

which varies from 6 to 18 inches in thickness, but it is said to have been poor.

Four crushings have been recorded from this lease, as may be seen by the table of statistics, having an average yield of over an ounce and a half to the ton:—

*Table showing the Yield of the Parnell North Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1900	.	.	.	.	46·50	162·00	3·48
1901	.	.	.	.	48·35	52·45	1·08
1902	.	.	.	.	60·00	54·90	·91
1903	.	.	.	.	41·50	41·00	·98
Total					196·35	310·35	1·52

At a point some distance to the north-west of the northern angle of G.M.L. 102 (146) an open-cut 187 feet in length has been put in on an east and west reef, occurring along the planes of bedding or foliation (?) of the schists, which at this point are vertical. There is, however, nothing to be seen, for all the workings have been filled in or are otherwise inaccessible.

BELLE VUE, G.M.L. 129.—This lease has been abandoned, and four men's quartz claim has been taken up upon it. The ground embraced by the claim includes the old workings. A shaft 53 feet deep has been sunk upon a quartz reef underlying at 15 degrees from the vertical and to the north. The present holders of the claim, Messrs. Underwood & Co., commenced operations when the present shaft had been carried down 25 feet from the surface. On the western face, at the foot of the shaft, which is about 10 feet distant, the reef is only about 4 inches thick, while at the eastern face the reef measures as much as 2 feet 3 inches. Under foot, at the bottom of the shaft, the average thickness is about 1 foot. A little water was oozing out from the walls at the foot of the shaft. The reef occurs along a line of fault, the country rock is slate, and the fault is parallel to the planes of bedding, which show numerous slickensided faces parallel to the underlie of the reef. The reef is extremely irregular in its thickness. Free gold is showing in the stone and the casing; a little iron pyrites is also present. The only crushing recorded from this lease was during the year 1902, when 34·40 tons of quartz yielded 116·50 ozs. of gold, or at the rate of 3·38 ozs. to the ton, showing conclusively that a very rich chute had been struck.

A short distance to the east of the Belle Vue is a reef about 3 feet in thickness, worked by Messrs. Ross and Wetherall. Although the stone is 3 feet thick, it is only the 4 inches along the

hanging wall of the reef which carries any gold. The reef occurs along the planes of foliation of the schists; no work, however, has been done upon it. A parcel of several tons is said to have yielded about 3 ozs. of gold to the ton; as the returns from this property do not appear in the official statistics under the name of Messrs. Ross and Wetherall, they are probably included under the heading of the yield from Sundry Claims.

The **SUDDEN JERK** is an unregistered claim, which has been taken up on an east and west reef occurring along the planes of foliation of the schists, which underlie at a high angle to the north.

A shaft was being sunk on the reef, which, at the date of my visit, had been carried down about 20 feet, and at the foot, on the western face, a "shear zone" of about 3 feet in thickness was exposed. This "zone" contained numerous quartz veins, mostly of small size; there, was, however, about a foot of quartz on the hanging wall. The reef on this property has been extensively worked along the outcrop for about 2 to 3 feet from the surface, but nothing very definite appears to be known as to its yield, which in all probability is included under the heading of Sundry Claims.

**RATTLER, G.M.L. 130** (formerly G.M.L. 93).—This is a 12-acre lease, situated about 160 chains to the south of the Two-Mile Well at Mosquito, but has long since been abandoned. So far as may be seen there are two parallel reefs upon the lease, which outcrop on the summit and flanks of the hill, upon which the old workings are situated. Near the base of the hill a tunnel has been put in 75 feet due north until it reached an east and west reef, from which about 66 tons of ore had been obtained. The country rock is plicated schist of the usual type, and the reef appears to occur along the planes of foliation. Nothing, however, can be seen of it at the present time. Little or nothing has been done upon the uppermost vein. The official statistics given below show, however, that the average return has been over 2 ozs. to the ton, from which it would appear that a rich chute had been met with:—

*Table showing the Yield of the Rattler Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1899	.	.	.	.	17·00	59·50	3·50
1901	.	.	.	.	22·00	29·00	1·32
1902	.	.	.	.	27·00	48·60	1·80
Total					66 00	137·10	2·07

**HUGH WILKIE'S CLAIM.**—A prospecting shaft had been sunk to a depth of 10 feet upon a vein of quartz 12 inches in thickness,



underlying to the north. The reef is encased in schist country of the type prevailing in the district. There were about 5 tons of quartz at grass.

GALTEE MORE, G.M.L. 79.—The Galtee More Reef traverses the whole length of the 6-acre lease near the northern boundary, and has been opened up in several places, but most of the workings are inaccessible at the present time. The average crushings since the year 1898 have been over  $2\frac{1}{2}$  ozs. to the ton, and over £900 is reported to have been spent on carting the stone to the battery, the charges being about £2, 10s. per ton.

There are two main shafts on the property; the easternmost shaft is 80 feet vertical, and is connected underground with the western shaft, 110 feet distant and 100 feet in depth. The 80-foot shaft has been carried down on the reef, from a point about 30 feet below the level of the surface. At the foot of the shaft the quartz is about 2 feet thick, occurring on the hanging wall of a "formation" of 4 feet in width. The "formation" consists of fissile and plicated slates or schists carrying a little iron pyrites and numerous quartz veins. The drive connecting the two shafts was inaccessible, and I am credibly informed the thickness of the quartz exposed did not fall below 18 inches. The western or 100-foot shaft struck the reef at 80 feet from the surface, and had been followed down upon the underlie for some distance. The thickness of quartz exposed varies from 12 to 18 inches. The underlie of the reef is not nearly so steep as in the other portions of the workings, suggesting that the reef has either (*a*) been faulted or (*b*) folded. About 300 tons of stone were at grass at the mouth of the deep shaft awaiting crushing. Considering the facilities for exploitation which this mine appears to possess, and the consistent high yield of the reef, as shown by the official statistics below, it is much to be regretted that the mining operations had not been more systematically carried out.

*Table showing the Yield of the Galtee More Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1898	.	.	.	.	16·00	69·00	4·31
1899	.	.	.	.	165·00	433·25	2·62
1901	.	.	.	.	199·00	401·95	2·02
1902	.	.	.	.	104·00	386·95	3·72
Total					484·00	1,291·15	2·66

GALTEE MORE WEST, G.M.L. 128.—A 12-acre lease, adjoining the last. A shaft, 110 feet in vertical depth, had been put down with the object of exploring the extension of the Galtee More Reef.

The shaft, however, was inaccessible, except at some personal risk, and no information was available.

**GALTEE MORE NORTH, G.M.L. 85.**—The name of this abandoned 17-acre lease implies that it is situated on the northern extension of the Galtee More Reef. This lease, however, lies 30 chains to the north of the latter, and the reef upon it trends generally east and west. Work ceased some years ago, and little or nothing is now to be seen of the workings. A small crushing of 17·25 tons yielded, in 1899, 35·20 ozs. of gold, or at the rate of 2·04 ozs. per ton.

**LATEST SURPRISE, G.M.L. 127** (formerly G.M.L. 88, Latest Surprise, and G.M.L. 78, Surprise).—A lease about 25 chains due west of the Galtee More group, embracing an area of about 6 acres. A shaft has been put down to a depth of 94 feet on an east-and-west reef underlying to the north at a very high angle. At the foot of the shaft the thickness of the reef is 15 inches. A drive 77 feet in length has been put into the west. At a point in the drive, 30 feet from the shaft, a second has been sunk to a depth of 50 feet from the floor of the level. A drive 10 feet in length has been opened out on the western side of the shaft, and a solid quartz reef of 24 inches in thickness exposed. The quartz contains a little carbonate of iron. The reef occurs in sheared slate, and apparently occurs along a line of fault. The sheared country rock contains small quantities of iron pyrites disseminated through it. In the eastern face, at the foot of the shaft, there is a thickness of about 3 feet of quartz. The ribboned zone contains lenticules of quartz. The reef has been worked to the surface from about 100 feet. The workings, which, however, are not extensive, are the deepest in this portion of the district.

Considering the high returns from this reef, as shown in the official statistics in the table below, and the facilities for exploitation which it presents, somewhat more systematic work would appear to be warranted.

*Table showing the Yield of the Latest Surprise Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1898	.	.	.	.	16·00	108·10	6·75
1899	.	.	.	.	44·25	84·00	1·89
1902	.	.	.	.	80·00	197·00	2·46
1903	.	.	.	.	108·00	179·00	1·66
Total					248·25	568·20	2·28

**ARD PATRICK, G.M.L. 143.**—A shaft has been sunk to a depth of 80 feet, and at 60 feet a quartz reef of 6 inches was struck. A drive has been put in 20 feet to the east, and the reef increased

to nearly 3 feet in thickness. The lower level at 80 feet was inaccessible, but it is said to have been driven 30 feet eastward and half that distance to the west. There were about 60 tons of quartz at grass, in which free gold was showing both in the stone and on the faces. The stone prospected well. There were about 60 tons of quartz at grass awaiting crushing.

**KING BILLY.**—An abandoned quartz claim. A quartz reef of no great thickness occurs on the north side of a vertical dyke of greenstone, striking north 75 degrees west. Not much work appears to have been done. The returns from this property are probably included in the yield of Sundry Claims, as shown in the official statistics. I have been credibly informed, however, that there have been two crushings—one of 8 tons, which yielded 15 dwts., and another of 20 tons, yielding 10 dwts. to the ton.

**LAST RESOURCE, Q.C. 223.**—A quartz claim held by Maurice Chaivi, W. Britten, and J. Corrin. A quartz reef, striking generally east and west, and underlying at a high angle to the south, has been opened up for about 100 feet along the outcrop by the previous holders of the ground.

A shaft about 80 feet in depth has been sunk on the reef, and drives put in to the east and west from the bottom. The western level has been driven 27 feet; at the foot of the shaft on the west the quartz is only 6 inches thick. The reef is continuous to the face of the drive, where there is about 12 inches of quartz showing underfoot. The eastern drive, which was inaccessible, is stated to have been carried 30 feet. The country rock is schist of the type prevailing in the district, and the reef occurs along a shear zone.

About 50 feet east is another reef, which has been opened up, but it is said to have been too poor to be worth working.

In 1903, a crushing of 9 tons is recorded as having yielded 13·50 ozs. of gold, or at the rate of 1·50 ozs. per ton; previous to this the yield has been shown under the heading of Sundry Claims. The total tonnage is said to have been about 50 tons, with an average yield of about 2 ozs. to the ton.

**MORTE CARLO WEST, Q.C. 235.**—A quartz claim held by Messrs. Connolly, Clemmenson, and Leonard. Nothing was to be seen underground at the date of my visit; the quartz reef occurred along the planes of foliation of the schists, which trend generally east and west, and dip to the north at a high angle. In 1903, about 20 tons of ore crushed yielded 52·80 ozs. of gold, or at the rate of 2·57 ozs. to the ton.

**MESSRS. PARK AND ROSS'S GROUND**, which would appear to have been abandoned, lies some miles to the north of Mosquito. The strike of the outcrop of the reef is 83 degrees, and occurs along the planes of foliation, which dip at a high angle to the south. The reef has been worked for some distance along the outcrop, and a considerable body of stone taken out. The reef has been followed down in one place to a depth of 33 feet. At the foot the width between the walls of the "formation" is about 2 feet, and



the total thickness of stone about 14 inches. The bulk of the quartz is on the hanging wall of the formation. A short distance lower down the eastern slope of the hill upon which the above reef outcrops, a drive has been commenced upon the outcrop of the reef (a line of fault), but only about an inch of quartz obtained. This drive is about 20 feet from the surface, and 20 feet above the level of the creek. Free gold is showing in the stone at grass.

The following is a synoptical table showing the yield of the reefs at Mosquito, in so far as may be gathered from the official statistics up to the close of 1903:—

*Synoptical Table showing the Yield of the Mosquito Creek Reefs.*

Name of Lease.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Bannockburn, G.M.L. 118 .	17·00	11·25	·66
Belle Vue, G.M.L. 129 . .	34·40	116·50	3·38
Federal, G.M.L. 97 (109) .	48·00	59·20	1·23
Galtee More, G.M.L. 79 .	484·00	1,291·15	2·66
Galtee More North, G.M.L. 85	17·25	35·20	2·04
Last Chance, Q.C. 208 . .	24·75	46·90	1·89
Last Resource, Q.C. 223 .	9·00	13·50	1·50
Latest Surprise, G.M.L. 127 .	248·25	568·20	2·28
Monte Carlo, Q.C. 219 . .	15·80	48·95	3·09
Monte Carlo West, Q.C. 235 .	20·50	52·80	2·57
Nichol's Reward, R.C. 74 .	450·15	649·52	1·44
Parnell, G.M.L. 95 . . .	357·35	384·40	1·07
Parnell North, G.M.L. 146 .	196·35	310·35	1·52
Parnell No. 1 West, G.M.L. 96	36·75	24·50	·66
Rattler, G.M.L. 130 . . .	66·00	137·10	2·07
Sundry Claims . . . .	614·24	966·06	1·56
Total . . . . .	2,639·79	4,715·58	1·71

**SANDY AND MIDDLE CREEKS.**—The Sandy and Middle Creek districts are embraced within a mineral zone which extends from Mosquito to Nullagine for a distance, as shown by the lithographs L 76, L 77, issued by the Department of Mines, of 24 miles. Geologically the districts are identical with that of Mosquito.

The following is a description of such of the mines as were open to inspection at the date the district was visited. The location of the most important will be found by reference to the lithographs enumerated above.

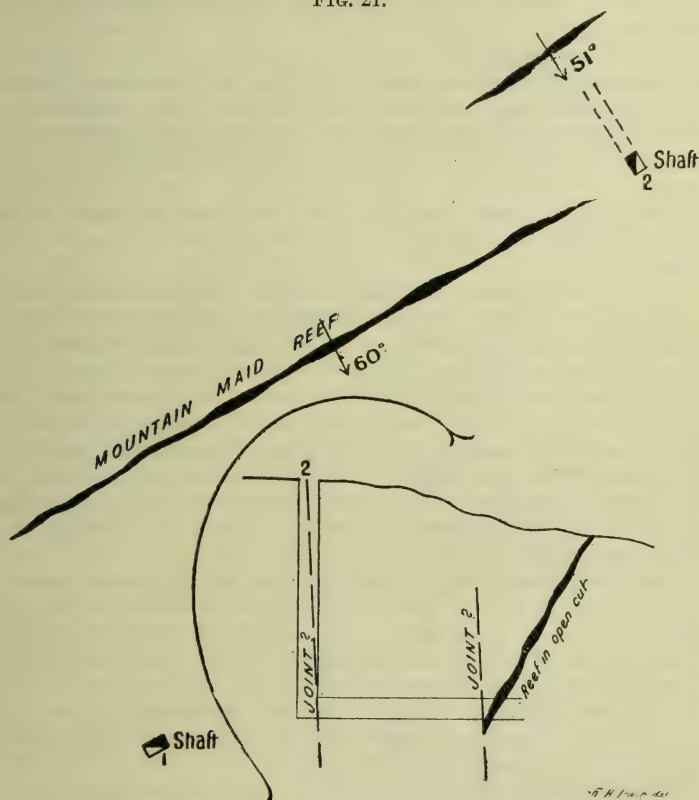
### THE REEFS

To facilitate reference, the properties are described in geographical order, commencing at the easternmost end of the field.

**THE REWARD (The Mountain Maid).**—The reef opened out on

this property is situated on the summit of a high ridge, bearing from the cairn west of M.A. 5, Sandy Creek, and east of the Galtee Moore Group, 104 degrees 30 seconds, and from the Battery Site, M.A. 5, 231 degrees. As measured along the outcrop the reef has an average strike of 58 degrees, with an underlie of 51 degrees to south 34 degrees east, and is a good solid body of quartz, averaging about 3 feet in thickness. The quartz is pure white, contains

FIG. 21.



PLAN & SECTION OF THE MOUNTAIN MAID REEF SANDY CR PILBARA G. F

a little green carbonate of copper, together with small quantities of iron pyrites. The country rock in the vicinity consists of shales and fine conglomerate, inclined at a high angle to the south. The reef has been prospected by means of two shafts 69 feet apart. The relative position of these is shown in the Fig. 21.

Shaft (1), 23 feet back from the outcrop, had been carried down through the country rock to its intersection with the reef,

40 feet below the level of the surface. No work was being carried out in the shaft.

Shaft (2), 20 feet in depth, through country rock; in the shaft there is a wall underlying to the north, which may be a line of fault, and possibly represents the continuation of the Mountain Maid Reef. From the foot of the shaft a crosscut has been put in to the north for a distance of 18 feet and cuts the reef at the bottom of the open cut on the brow of the hill to the north. In the crosscut it appears as though the reef is cut off by a fault parallel to the one showing in the shaft.

There are about 20 tons of quartz at grass. It is stated on reliable authority that one crushing of 6 ozs. and another of 26 dwts. to the ton have been obtained from this reef. The annual official statistics do not show any separate yield from this property, any returns being probably included under the heading of Sundry Claims.

ROUND HILL (Mr. McColl).—Two men were at work at the date the locality was visited. There are several workings on this claim.

An inclined tunnel 43 feet in length, driven on a bearing of 277 degrees, the section in the tunnel which has been carved out of almost vertical slates, shows from the slickensided faces that the reef is along a fault. At one spot in the tunnel there is about 3 feet of quartz, but at the face practically no stone is showing; the reef underlies to the south. Twenty-six feet from the mouth of the tunnel, and on a bearing of 136 degrees 30 minutes, a shaft was being sunk, with the object of intersecting the tunnel reef, and then driving westward underneath the workings. Free gold was showing in the loose rubble lying at the surface near the mouth of the tunnel, and the shaft.

There are several roughly parallel reefs on the ground, some of which have been merely opened up, but no other work done upon them. They all lie parallel to the planes of either bedding or foliation of the country rock. A shaft had been sunk to a depth of about 10 feet on a vertical reef 18 inches in its thickest part. At the bottom of the shaft, however, there is only 6 inches of quartz.

There was virtually no stone at grass except such as has been left by previous prospectors.

BOW BELLS CLAIM.—There are two reefs on the property—an eastern reef striking 232 degrees and underlying west, and a western reef about 23 feet distant, which strikes 254 degrees and underlies to the east. The eastern reef has been opened up along the surface for a distance of about 40 feet, and at the southern end of the trench excavated to a depth of 10 feet. The reef outcrops for a considerable distance both north and south of the trench, but very little work would appear to have been done upon it. The thickness of the reef varies from 1 to 3 feet. Stone taken from the reef shows free coarse gold. Some crushings are said to have been obtained from this reef; the returns, however,



are probably included under the heading of the yield from Sundry Claims. The western reef has been opened up for 120 feet along the outcrop. The greatest depth at which the reef has been followed is 10 feet. The quartz varies in thickness from 1 to 4 feet. About 5 tons of quartz had been raised, and were awaiting crushing at the date of my visit.

CENTRAL, G.M.L. 137 (formerly G.M.L. 126).—A 12-acre lease held by Mr. McGuire is situated in a locality to the west of Camel Creek, in which many reefs outcrop.

A vertical shaft 130 feet deep has been put down on a reef having an average strike of 78 degrees. The reef has been opened out on the surface 130 feet west of the shaft and 100 feet east of it. The average thickness of the reef is a little over 6 inches. From a point about 63 feet east of the vertical shaft the reef has been stoped to a depth of 30 feet, and to a similar depth on the west from about 30 feet west of the shaft. At a depth of 100 feet an eastern drive has been put in for a distance of 33 feet, and at the face there are from 6 to 8 inches of quartz showing; the face of the western drive is 21 feet from the shaft, but the reef is only represented by about 1 inch of quartz. About 80 to 90 tons of quartz had been raised, and were awaiting crushing.

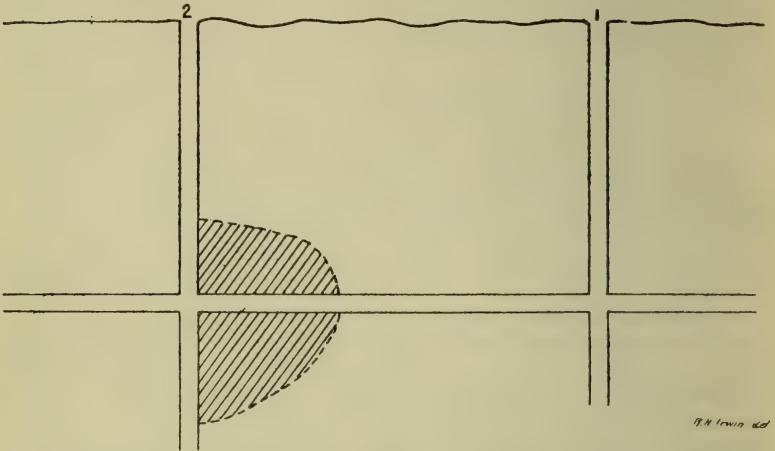
In the year 1902, 35·75 tons of quartz were raised and crushed, and the yield, as shown by the official statistics, amounted to 125·85 ozs. of gold, or at the rate of 3·52 ozs. to the ton.

LITTLE WONDER, G.M.L. 136.—There are two shafts upon this lease, 120 feet apart, and connected by a level at 76 feet from the surface, as shown in Fig. 22. The outcrop of the reef bears 130 degrees. At the 76-foot level in the southernmost shaft the reef has been worked out to about 20 feet above the drive to the north-west; here a very rich crushing of about 10 ozs. is said to have been obtained. A drive has been put into the north for a distance of 19 feet, and at the face is an inch of quartz; the drive is through country all the way.

Along the drive connecting the two shafts the reef varies from 9 inches to 5 feet. No. 1 shaft has been put down on the reef all the way from the surface. About 9 inches of quartz is exposed at the foot of the shaft. At the face of the drive, about 15 feet west from the shaft, the reef is represented by only a few inches of quartz. From shaft No. 2 the drive has been continued to the east for a distance of 49 feet, on practically no quartz, but all formation. From the foot of shaft No. 2 a crosscut has been put in to the north for a distance of 16 feet to the reef, through formation. An easterly drive has been continued 30 feet along the reef. Eighteen feet up from the bottom of the shaft there is a thickness of 10 feet of quartz, carrying only 1 foot of formation. A 6-oz. crushing is said to have been obtained from this portion of the reef. From what can be seen in this portion of the workings it appears that the Little Wonder Reef is exceptionally irregular in its behaviour, and the rich patches hitherto opened up

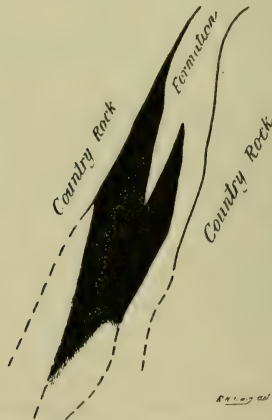
occur in the wider portions of the lenticular veins. The Fig. 23 gives an illustration of the occurrence of the reef in the shaft

FIG. 22.

LONGITUDINAL SECTION OF THE WORKINGS ON THE LITTLE WONDER REEF SANDY C<sup>M</sup> PILBARA G. F.

below the 76 feet level. From the slickensided faces, &c., it appears that the reef occurs along a line of fault. About 12 tons

FIG. 23.

SECTION OF THE LITTLE WONDER REEF SANDY C<sup>M</sup> PILBARA G. F.

of what was believed to be rich stone was at grass at the date of my visit, together with 200 tons of seconds, a trial crushing of

about 20 tons of which are said to have yielded 16 dwts. of gold per ton.

According to the official returns, the Little Wonder Reef has crushed 344 tons of ore for an average yield of over 7 ozs. of gold per ton ; it certainly warrants a systematic scheme of development.

*Table showing the Yield of the Little Wonder Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1902	.	.	.	.	63'00	624'90	9'92
1903	.	.	.	.	281'00	1,882'37	6'69
Total					344'00	2,507'27	7'05

LITTLE WONDER WEST, G.M.L. 138L.—There are two shafts upon this reef, which is believed to be the extension of the Little Wonder. The westernmost shaft has been carried down 21 feet on a formation 3 feet wide, carrying quartz veins. One of these measured about 20 inches across, but at the foot of the shaft it proved to be much smaller. This reef is said to have prospected up to 4 ozs. per ton at the surface, but proved to be very poor at the bottom. There are about from 10 to 15 tons of stone at grass. The eastern shaft has been sunk to a total depth of 103 feet; the shaft being sunk 33 vertically to the reef and continued for a farther distance of about 70 feet on the underlie, which is at 45 degrees to the north. From the foot of the shaft drives have been put in to the east and west for distances of 60 and 40 feet respectively. The reef occurs along a line of fault, but there is very little stone showing. A small 4 oz. crushing is said to have been obtained from the outcrop of the reef.

EUREKA, G.M.L. 139.—A vertical shaft sunk to a depth of 110 feet on a "formation" with a little rubbly quartz, in reality "fault rock." At 70 feet the width between the walls is 7 feet; the best gold is said to have been obtained from the stone on the hanging wall. From a depth of 110 feet, a portion of the shaft inaccessible at the date of my visit, a crushing of 20 tons is said to have yielded an average return of 4 dwts. to the ton. A shaft some distance to the north-west of this has been put down to a depth of 20 feet, on a small quartz leader, but no other work has been done.

During 1903, the official statistics demonstrate that 82·20 tons of ore from the Eureka property yielded 75·65 ozs. of gold, which works out at the average rate of '92 ozs. to the ton.

FEDERATION, Q.C. (originally G.M.L. 91).—Work was being carried on on a quartz reef 8 to 10 inches in thickness, having an average strike of 234 degrees, and an underlie to the north-west. The reef outcrops on the eastern face of a ridge, and forms the



highest summit of it. The reef occurs along a line of fault, and was being worked by means of an open cut 10 feet in depth and 30 feet in length at its deepest point, and about 18 tons of ore have been raised. The prospectors informed me that there is about 10 feet of the country rock on either side of the reef, which carries gold up to about 10 dwts. A good deal of desultory work appears to have been done on the property by the previous holders of the ground, and the official returns show that the yield has been over 3 ozs. to the ton.

At the western end of the property a good deal of work has been done on a "formation reef" bearing 100 degrees. This deposit is a "shear zone," several feet in width, and intersected by irregular quartz veins. It is stated that 160 tons of this yielded 11 dwts. per ton. These figures, however, do not appear in the published annual returns, and may possibly be included under the heading of the yield from Sundry Claims.

*Table showing the Yield of the Federation Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1899	.	.	.	.	49·50	152·15	3·07
1900	.	.	.	.	5·50	17·70	3·21
Total					55·00	169·85	3·08

FEDERATION EXTENDED, G.M.L. 92.—An adjoining lease of 5 acres, which, however, is now abandoned, and nothing is to be seen. In the year 1900, 6 tons of ore are reported officially to have yielded 31·10 ozs. of gold, or at the rate of 5·18 ozs. to the ton.

ALL NATIONS (formerly G.M.L. 82, 108).—Ten acres. The general strike of the reef is 4 degrees 30 seconds. A new main shaft has been put down at the northern end of the ground. Although a good deal of work must have been done in previous years, very little is to be seen at the present time.

The official returns from this lease are as follows:—

*Table showing the Yield of the All Nations Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1899	.	.	.	.	136·00	432·40	3·18
1900	.	.	.	.	132·00	223·80	1·69
1901	.	.	.	.	61·00	148·50	2·43
1902	.	.	.	.	67·50	58·11	·86
1903	.	.	.	.	5·00	5·30	1·06
Total					401·50	868·11	2·11

ALL NATIONS SOUTH, Q.C.—A quartz reef from 1 to 3 feet in width, having an average strike of 20 degrees. The reef has been worked by an open cut for 95 feet along the outcrop; and at its southern end is a shaft 25 feet in depth. The deposit is a fault line along the foliation (? bedding) planes of the schists. There are about 22 tons of stone at grass awaiting crushing. It is not quite clear whether this ground is embraced within the limits of the old All Nations Lease.

KINGSMILL, Q.C.—The Kingsmill Reef has an average strike of 344 degrees, with an underlie to the west. An underlie shaft has been sunk to a depth of 57 feet. At the bottom of the shaft the width between the walls of the formation carrying the reef is as much as 5 feet, although there is only 12 inches of quartz on the hanging wall. A drive has been put into the south for a distance of 20 feet, along the formation; at the face a few quartz stringers are showing. The stone has been stoped out to a point about 9 feet from the head of the drive. There are about 30 tons of quartz awaiting crushing. In 1903 the official returns show that 24 tons of ore crushed yielded 48 ozs. of gold, or at the rate of 2 ozs. to the ton.

TRIPLE ALLIANCE, Q.C.—The Triple Alliance has an average strike, as measured along the outcrop of N. 56 E., with an underlie to the south-east. A vertical shaft 24 feet in depth has been put down upon it. At 20 feet the reef is only from 6 to 8 inches thick, but its size has increased at the foot of the shaft to from 3 to 4 feet. The country rock is slate. The same reef has been opened up by an underlie shaft, a few feet farther to the north, but owing to the shaft being filled in nothing can be seen of its character. At the surface, however, its thickness is 12 inches. A crushing from this shaft is said to have yielded an average return of 26 dwts. to the ton; there were about 2 tons of stone awaiting crushing. This, what may be called the "main reef," is crossed by another underlying south and trending east and west. A second reef parallel to the main body lies 78 feet distant, on a bearing of 341 degrees, but no work has been done upon it.

YES OR NO, Q.C. (formerly G.M.L. 90).—A quartz reef striking north-east and south-west has been opened up for some distance along the outcrop. A vertical shaft 80 feet in depth has been

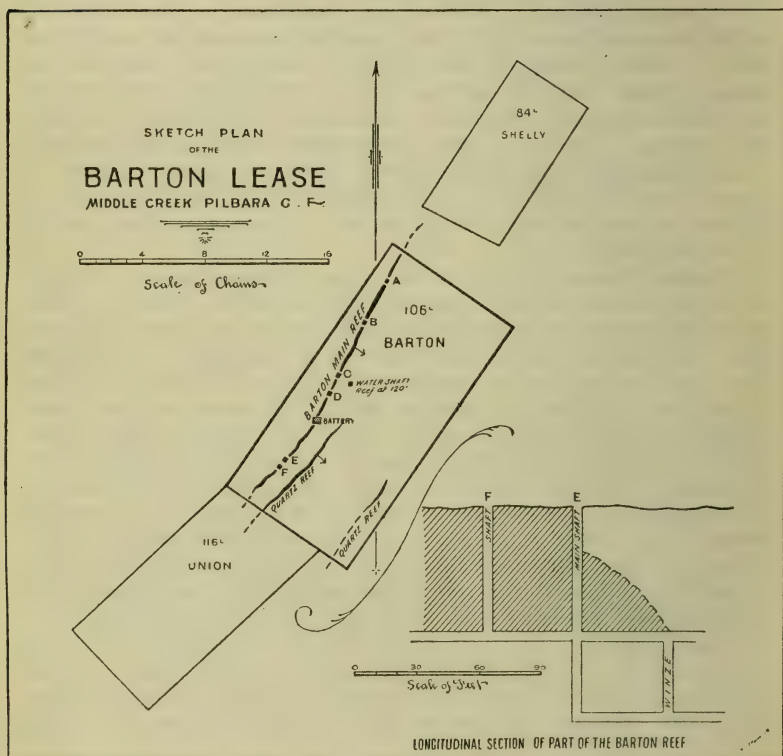
*Table showing the Yield of the Yes or No Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1899	.	.	.	.	19'00	39'50	2'32
1903	.	.	.	.	15'00	60'00	4'00
Total					32'00	99'50	3'10

put down at a point 29 feet back from the outcrop, and met with the reef at the bottom. The reef was followed on the underlie for a distance of 30 feet farther. About 7 or 8 tons of stone had been raised, and awaited crushing.

BARTON, G.M.L. 109.—The Barton Reef is one of the most continuous in the district yet examined. It traverses practically with little or no interruption G.M.Ls. 116, 106, 84, and possibly M.L. 11, and G.M.L. 113; the location may be seen by reference to the

FIG. 24.



40 chain lithograph issued by the Department of Mines. The Barton Reef is strong and well-defined; it enters G.M.L. 106, on the southern boundary of the lease, at about 100 feet from the south-west corner, and continues without interruption to the northern boundary of the lease, thus having a proved outcrop of at least 1250 feet.

As may be seen by the sketch plan forming Fig. 24, the deposit has been opened up by six shafts put down along the outcrop of the reef. In addition to this the reef is intersected in the water-shaft



(distant 58 feet from C) at about 120 feet from the surface. Shaft A, which was inaccessible, has been carried down on the reef to a depth of 15 feet, at the foot of which it is stated that the reef attained a thickness of 6 feet. Shaft B was likewise inaccessible, and attained a depth of 30 feet. Shaft C had been carried down on the reef to a depth of 65 feet, but beyond sinking the shaft nothing appeared to have been done. At the foot of the shaft the reef measures about 4 feet from wall to wall, and from the information supplied to me by the Manager it would not appear to have proved payable at the bottom. Down to about 53 feet the stone is stated to have been payable. It is contemplated continuing this shaft by following the reef down to the depth at which it is met with in the water-shaft, viz., 120 feet. Shaft D had, at the date of my visit, been carried down to a depth of 40 feet. At the foot of the shaft a drive had been put in for a distance of 35 feet northwards, and the stone stoped out to about 10 feet from the surface. Southwards from the shaft the drive had been continued for a distance of 40 feet along the reef, which varied from 7 to 8 feet in thickness. The stone has been stoped out to within 10 feet of the outcrop from this level. Shaft E attains a depth of 110 feet, and has been carried down on the reef, the underlay of which is about 65 degrees to the south-east. At a depth of 60 feet levels have been opened up to the north and south for distances of 40 and 80 feet respectively. In the northern drive, 40 feet from the shaft, a winze has been carried down to the 110-foot level; the reef is represented by a schistose formation, intersected by several quartz veins. The reef has been stoped out for a distance of 40 feet along this drive to a point about 20 feet from the mouth of the shaft. The southern drive has been carried for a distance of 80 feet from the main shaft, and at 39 feet therefrom it intersects shaft F, which is 60 feet deep. The maximum thickness of stone in this drive is 8 feet 8 inches. The whole of the stone in this drive has been stoped out to within 3 feet of the outcrop. The main shaft has been continued from the 80-foot level down to 110 feet, from which point a level has been driven 95 feet to the north. The reef at the foot of the shaft, as showing on the south side, is 4 feet thick, and at the face of the drive it has dwindled down to 12 inches. No work has been done at this level.

As shown by the official figures, the average yield of the Barton Reef has been just over an ounce and a quarter to the ton.

There is a 10-head stamp battery, one berdan pan, two boilers and engines, and two steam pumps on the lease.

This battery is available for public crushing at the following rates:—For parcels up to 20 tons, 35s. per ton; and 30s. per ton for any quantity over that. During the year 1901, 1902, and up to the end of November 1903, the stone crushed for the public amounted to 1,693·71 tons, yielding 5,940·40 ozs. of gold, whilst the stone from the Company's own property is as set forth in the following table:—

*Table showing the Yield of the Barton Reef.*

Year.		Ore Crushed.	Gold therefrom.	Rate per Ton.
		Tons.	Ozs.	Ozs.
1898 . . . . .		56·00	88·50	1·58
1899 . . . . .		30·00	18·30	·61
1900 . . . . .		144·00	204·20	1·41
1901 . . . . .		356·65	373·10	1·04
1902 . . . . .		622·00	876·60	1·40
1903 . . . . .		802·00	1,046·20	1·1
Total . . . . .		2,010·65	2,606·90	1·31

UNION, G.M.L. 116.—The Union Reef, which has an average strike of 196, has been opened up by means of a tunnel 64 feet in length, which has been driven on a bearing of 289 degrees. The reef is intersected at the face of the tunnel, and measures 4 feet in thickness. Any returns from this property are included under the heading of the yield of Sundry Claims, as shown in the official statistics.

MUNDALLA, Q.C. 215 (G.M.L. 103).—A 6-acre lease lying some distance to the north-east of Castle Rock. There are some old workings on the property which are hardly accessible; the reef opened up runs east and west. A main vertical shaft has been carried down to a depth of 130 feet. From the foot of the shaft a crosscut 28 feet in length has been put into the reef, which lies to the north. The reef is vertical. At the face of the crosscut is an old shaft, which had been put down on the reef. From the drive the reef has been stoped out up to the surface. A winze 34 feet deep has been sunk 19 feet west of the shaft. The quartz is showing in the western face of the winze only 4 inches in thickness. Slickensided faces occur on the quartz on the hanging wall of the reef. The ground is damp, indicating an approach to the water level. The quartz carries a little galena and iron pyrites.

According to the official returns as shown in the table below, the Mundalla reef has had an average yield of over 5 ounces to the ton.

*Table showing the Yield of the Mundalla Reef.*

Year.		Ore Crushed.	Gold therefrom.	Rate per Ton.
		Tons.	Ozs.	Ozs.
1900 . . . . .		91·30	334·95	3·66
1901 . . . . .		92·00	573·30	6·23
1902 . . . . .		30·00	266·80	8·89
Total . . . . .		213·30	1,121·70	5·25

The following is a synoptical table showing the yield of the reefs of Sandy and Middle Creeks up to the close of 1903, so far as can be gathered from the official figures:—

*Synoptical Table showing the Yield of the Sandy and Middle Creeks Reefs.*

Name of Lease, &c.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
All Nations, Q.C. (G.M.L. 108) . . . . .	401·50	868·11	2·11
Barton, G.M.L. 106 . . . . .	2,010·65	2,606·90	1·31
Central, G.M.L. 137 (126) . . . . .	35·75	125·85	3·52
Daisy, G.M.L. 89 . . . . .	21·00	64·20	3·05
Dominion, Q.C. 205 . . . . .	10·50	14·71	1·40
Eureka, G.M.L. 139 . . . . .	82·20	75·65	·92
Federation, Q.C. (G.M.L. 91) . . . . .	55·00	169·85	3·08
Federation Extended, G.M.L. . . . .	6·00	31·10	5·18
Gem, Q.C. 214 . . . . .	20·50	32·80	1·60
Hidden Treasure, Q.C. 126 . . . . .	28·00	28·00	1·00
Kingsmill, Q.C. 221 . . . . .	24·00	48·00	2·00
Little Marvel, Q.C. 233 . . . . .	8·00	32·00	4·00
Little Wonder, G.M.L. 136 . . . . .	344·00	2,507·27	7·05
Mundalla, Q.C. 215 (G.M.L. 103) . . . . .	213·30	1,121·70	5·25
Triple Alliance, Q.C. 196 . . . . .	10·00	50·00	5·00
Yes-No, Q.C. 218 (G.M.L. 90) . . . . .	32·00	99·50	3·10
Sundry Claims . . . . .	499·90	1,049·88	2·10
Total . . . . .	3,802·30	8,925·52	2·32

The above figures may not accurately represent the total yield from the Middle and Sandy Creek centres, owing to the fact that it has not been possible to satisfactorily separate the returns of sundry claims from those credited to the adjoining centre of Nullagine.

GENERAL.—The Mosquito, Sandy, and Middle Creek districts are embraced within a mineral belt which extends from Nullagine to Mosquito for a distance, as shown by the official maps of the Mines Department, L. 76, L. 77, of about 24 miles. Over the whole distance numerous quartz reefs outcrop over a belt of about a couple of miles or so in width. Many of these reefs have been opened up at one time or another and worked, although a good deal of the work cannot be regarded as having been systematically carried out. None of the workings which were accessible to me had reached anything like 200 feet in depth. An examination of such of the mines as were open to my inspection demonstrated that the deposits gave every promise of being permanent, though they naturally varied in their dimensions and richness in different portions. According to the official figures, it appears that the country between Mosquito and Castle Creek has yielded gold to the extent of 19,157·41 ozs., which has been extracted from 8,872·24 tons of quartz, being at the average rate of 2·16 ozs. per ton; from these figures it will be seen that some high-grade ore has



been raised, though it must be remembered that, under the conditions prevailing, only rich ore can be mined at a profit. Of the 57<sup>1</sup> crushings recorded from the district lying between the two localities, it appears that 7 yielded under 1 oz. of gold to the ton, 24 up to 2 ozs., 11 up to 3 ozs., 8 up to 4 ozs., and the remaining 7 fluctuated between 5 ozs. and 9 ozs.

**CRUSHING FACILITIES.**—The present crushing facilities in the district of Mosquito, Sandy, and Middle Creeks comprise the Barton Mill at Middle Creek, the Parnell Battery, owned by the Bell Exploration Company at Mosquito, and the Royer's Public Crushing Battery on M.A. 6, Mosquito Creek. What is known as the Lady Ray Battery was originally erected on M.L. 5, at the 20-mile Sandy, and crushed for the public during the years 1900 and 1901. This battery was subsequently removed, and is now stored at the Barton, and may possibly be erected in conjunction with the present mill, if developments at the mine so warrant.

The Barton Battery is available for crushing at the following rates: For parcels up to 20 tons, 35s. per ton; and 30s. per ton for anything over that. During the three years ending 1903, it appears that the public stone crushed at the Barton Mill practically equalled that from the Company's own lease, or, approximately, about 50 tons per month.

The Lady Ray Battery, originally located on M.L. 5 at 20-mile Sandy Creek, crushed for the public during the years 1900 and 1901 647·85 tons of stone, which yielded 981·54 ozs. of gold, or about 27 tons per month.

The Royer's Public Crushing Battery treated, since it was erected in 1900, 1893·10 tons of stone, with a yield of 2928·95 ozs. of gold, or about 52 tons per month.

The Parnell Battery, according to the official statistics, crushed 120·50 tons of public stone, and returned 221·45 ozs. of gold, or roughly, about 10 tons per month. Under an agreement recently entered into with the Government, the owners of the battery have received State aid in consideration of the mill being available for public crushing during a stipulated number of days per month, at the following rates: For less than and not exceeding 50 tons, 30s. per ton; and for anything over 50 tons, 25s. per ton. This rate is the lowest in the district at the present time for parcels over 50 tons.

There is no question that could crushing be carried out at lower rates than those at present prevailing, stone that must, under present conditions, be left would be raised and milled, for a few shillings less for crushing (and carting) makes all the difference between profit and loss.

It was pointed out to me by a deputation, consisting of representatives from the prospectors and leaseholders which waited upon me by request at 20-mile Sandy, that all the gold in the ore treated at the different private crushing plants was not recovered,

<sup>1</sup> Taking the annual return from each mine or claim as representing one crushing.—A.G.M.

that this represented a considerable loss to them, and they urged the establishment of a properly equipped State mill.<sup>1</sup> Upon this point I am not in a position (for obvious reasons) to throw any other light than to merely draw attention to the returns obtained at the Lambert's Treatment Works, M.A. 41, where certain tailings from the district have been cyanided:—

*Table showing the Yield of the Tailings cyanided at Lambert's Treatment Works.*

Year.					Tailings Cyanided.	Gold therefrom.
					Tons.	Ozs.
1902	.	.	.	.	1960	1259·05
1903	.	.	.	.	840	379·45
Total					2800	1638·50

Owing to the way in which the returns are furnished, it has not been possible to separate the yield of the tailings from each centre. These data, so far as they go, show *prima facie* that the statement regarding the loss of some of the gold is based upon reasonable grounds.

Two assays of tailings from this neighbourhood have been made in the Survey Laboratory, and gave the following results:—

4518 . . . Gold . . . 1 oz. 8 dwts. 20 grs. per ton.  
169B . . . Gold . . . 19 dwts. 14 grs. per ton.

The initial figures refer to the numbers in the laboratory sample book.

**TIMBER.**—The supply of timber for mining purposes is not, over this portion of the district, abundant, and, having regard to future serious mining operations, may practically be said to be non-existent. Wood for fuel is mostly to be obtained from the banks of the water courses traversing the district, and at the present time, owing to the diminution of the supply in close proximity to the workings, much greater distances have to be traversed to obtain it.

**WATER SUPPLY.**—Over the whole district between Mosquito and Nullagine it cannot be said that the water supply is good. Wells sunk in the granite area of Mosquito yield practically no supply unless after heavy rains. This rock not being, below the level of the weathered zone, sufficiently porous to allow of the absorption and transmission of water, and even at greater depths likely to be more compact owing to pressure, &c., there is but little hope of increasing the supply from this source by either the deepening of the existing wells or the sinking of others. Fissures,

<sup>1</sup> A report upon this question has been submitted, and will be found *in extenso* in the Annual Report of the Geological Survey for the year 1903.—A.G.M.

either joints, faults, or bedding planes, may, of course, allow the water to be carried below the weathered zone, or the level of permanent saturation; but the chances of a well or bore hole striking such a fissure are so small that any expenditure incurred in the hope of increasing the supply by such means could hardly be expected to prove successful.

The strata of the other portions of the district are affected by weathering to such an extent as to allow of the percolation and transmission of water to depths depending, amongst other causes, upon the nature of the individual rocks. Some of the weathered portions of the sandstones and grits associated with the schists are eminently suited for the absorption and transmission of water.

A good supply of water occurs in the old water shaft on the Machine Area at Sandy Creek, and might be made available for public use after the officers of the water supply department have satisfied themselves that the supply would be adequate to meet the drain upon it. Whether any supply so obtained would be likely to be suitable for domestic use depends upon the fact that any water which percolates beneath the surface dissolves the soluble constituents to an extent which would appear to depend on the composition of the rock it traverses, the depth and the time it remains confined. Many of the schistose rocks in the area in question are of such a composition as would naturally cause any water traversing them to become mineralised to such an extent as might render it unsuitable for domestic use. On the other hand, the quartzose, sandstone, grits, and allied rocks associated with them are of such a character that any water falling upon and being absorbed by them would naturally be expected to be, at any rate, relatively free from mineral impurities.

Boring or sinking for water, if intelligently carried out, having due regard to the geological conditions prevailing, may be reasonably expected to result in obtaining supplies at any rate suitable for such requirements as do not entail what may be called a constant draft upon the supply.

CARTAGE.—It may be noted in this connection, Mr. Downes, the Public Works District Engineer, writing in 1890 upon the "40-mile Country" (*i.e.* the country between Nullagine and Mosquito Creek), remarked:—

"As a general rule, tracks for carting are fairly easy to find through the country, and are usually fairly level, and nearly always have a hard and fairly even surface; yet the great distances that have to be traversed to the only battery working, together with the uncertainty of horse feed and water supply, render carting at present so costly an item that in the more distant parts of the district it takes  $1\frac{1}{2}$  ozs. and even 2 ozs. per ton to pay cartage, crushing, purchase of explosives, &c., the men only commencing to make wages when the grade of the stone is above this percentage. The consequence is that, generally speaking, nothing under 2 ozs. per ton reefs are at present worth touching, and all reefs of lower grade than this are let severely alone, though, with improved facilities, these comparatively low-grade ores will prove a great source of wealth in the future. Stores and material are almost entirely carted from Port Hedland to Nullagine, a





The Hon. H. Gregory M.L.S.A.  
Minister for Mines



GEOLOGICAL SKETCH MAP  
OF

**MOOLYELLA TINFIELD**

PILBARA G. F.

BY

**A. GIBB MAITLAND**

GOVERNMENT GEOLOGIST

and

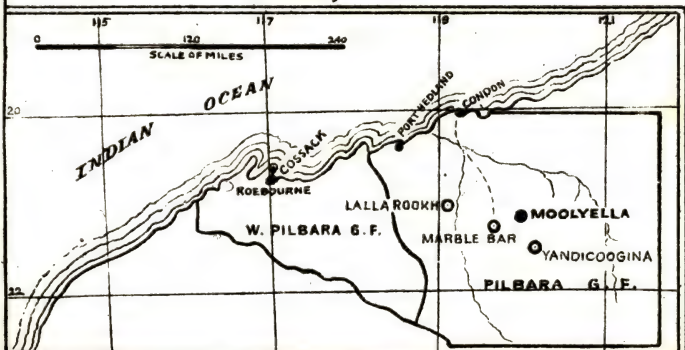
**H. W. B. TALBOT**

FIELD ASSISTANT

1903

SCALE OF CHAINS

Locality Plan

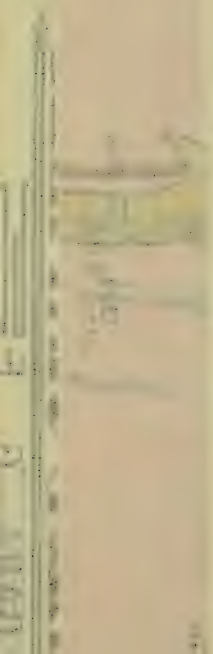


ALLUVIAL FLATS	
PEGMATITE (Tin bearing)	
GRANITE	
QUARTZ REEFS	
TIN WORKINGS	
GEOLOGICAL BOUNDARIES	
EXTINCT LEASES	

*A. Gibb Maitland*  
Government Geologist

R.N. Irwin del. 30/1/04





distance of 183 miles, of which 70 miles near the coast is very heavy, and some little of the remainder is rough and rocky. . . ."<sup>1</sup>

The above description sets forth the condition of affairs as it appeared in 1899, and at the present time practically the same may be said to prevail. To Nullagine and the Mosquito Creek neighbourhood cartage costs at the present time from about £17 to nearly £20 per ton.

### I.—The Moolyella Tinfield

*(With a Geological Sketch Map.)*

The Moolyella Tinfield, as defined by the authorities, is situated on the relatively high granite tableland, drained by the head waters of Brockman's Creek, Talga River and their tributaries, all of which fall into the Coongan River. The principal productive area embraces about 9 square miles of country, and is depicted on the geological sketch map attached.

HISTORY.—Tin appears to have been first discovered in this locality in the year 1898, and the samples submitted to this office assayed 68·1 per cent. of metallic tin. During this year the production amounted to 75·45 tons, valued at £4419. During the year 1899 considerable progress appeared to have been made in the exploitation of the tin field, in that during that period 42 leases, embracing an area of 1181 acres had been taken up, and of these 1059 acres are stated to have been actually worked. The amount of tin reported only totalled 57·50 tons, valued at £3612; of this, however, only 29·55 tons, valued at £2025, were exported from the State during the year. There seem to be good grounds for believing that the quantity of tin reported does not actually represent the total production for the district during the year. The year 1900 showed a marked increase in the output of black tin, owing to the fact that the tinfield was worked during the whole 12 months. The official records show that black tin to the extent of 387·87 tons, valued at £27,174, was officially reported to the Government, but the Warden, in his report for the year 1900, states that—

“As there were a number of alluvial diggers working who obtained tin of which no return can be got, the total output must have been larger.”

Of the quantity of black tin recorded from Moolyella during 1900, it appears that only 368·34 tons, valued at £30,146, was exported from the State. During 1901 very few tin mining leases appear to have been worked, most of the ground being held as claims, and despite this the output of black tin showed a marked increase, for 412·98 tons, valued at £21,148, were raised. The year 1902 showed a noticeable decrease in the output of black tin from the Moolyella centre, there being only 104·55 tons of ore, valued at

<sup>1</sup> Annual Report of the Department of Mines for the year 1899. Perth: By Authority, 1900, p. 146.



£7407. A slight increase in the output for the year 1903 is recorded, there having been reported 569·28 tons, valued at £37,885.

### GENERAL GEOLOGICAL FEATURES

The Moolyella Tinfield presents a remarkable uniformity in its geology, the whole area being formed of a granite, composed of quartz, felspar, and mica. The granite covers a very wide expanse of territory, extending over an area of about 900 square miles, in the country lying to the east of the Coongan River, to the west of the Nullagine, and to the south of what may be called the Marble Bar-Yandicoogina auriferous zone. A similar area of stanniferous granite occupies the country to the west of the Coongan River, and included within its boundaries the tin-mining centres of Cooglegong, Wodgina, and the Shaw, which will form the subject of examination next season.

The granite of the Moolyella type often passes into a very coarse-grained rock [5398], containing quartz, mica, and felspar.

The granite, as may be seen by an inspection of sections along its margin, is clearly intrusive, for it has eaten its way into the schists, and in the vicinity of Bamboo Creek it sends veins and bosses into them.

The age of the granite cannot yet be definitely ascertained, although it passes beneath the sedimentary beds of Bamboo and Yandicoogina, which, according to the meagre evidence available, are inferentially assumed to be Cambrian.

As may be seen by an inspection of the geological map, the Moolyella granite is traversed by several north and south quartz reefs, some of which are over 50 chains in length, and a series of pegmatite (?) [5397] veins. These pegmatite veins exhibit, when laid down upon a map, a general parallelism; they trend gradually north and south, conforming in this respect to the strike of the quartz reefs.

The upheaval of the granite mass, and the stresses and strains resulting therefrom, induced along an axis, having north and south direction, has resulted in the production of a series of joints, &c., which has formed the channels up which mineral-bearing solutions have percolated and deposited in the one place free quartz, forming the persistent reefs, and in the other have attacked some of the constituents of the granite. The result of this chemical action has been the production of a rock [5397] made up principally of quartz, albite, a little mica, together with a few garnets and cassiterite. The composition of the rock is shown in the table on page 7.

Deposits of this kind, which owe their origin to deep-seated causes, are as likely to be permanent as any ore deposits can ever be.

Practically all the tin hitherto obtained from Moolyella is derived from the alluvial deposits formed in the existing valleys,

all of which are shown upon the geological map. As this portion of the field was practically a blank on the existing maps, it was found necessary to prepare a plan of the vicinity in which mining operations had been carried on. The work was carried out by means of a plane table and tape measure. The topographical and geological features are as accurate as the scale of the map, the time at my disposal, and the necessities of the work demanded.

The alluvial deposits do not attain any very great thickness, although in some places their width exceeds 10 chains. The tin ore found in the alluvium is very much waterworn and rounded [5399, 5400].

In addition to the alluvial deposits, a large quantity of residual tin, *i.e.* ore derived from the decomposition *in situ* of the tin-bearing pegmatites, occurs all over the field. This form of tin ore is very ragged and angular [5403]. Some very good prospects were obtained by Mr. Talbot, the Field Assistant, by dry-blowing the surface *débris*, along the face of an almost horizontal pegmatite vein, occurring about 16 chains west from the western boundary of the Independent M.L. 45. Careful search along the outcrop of the vein resulted in finding tin in the rock itself. These residual deposits, occurring as they do all over that portion of the granite area which is reticulated by pegmatite veins, afford a good standby for prospectors at such times as prospecting in other portions of the district becomes impossible. The occurrence of pegmatite veins over such a considerable portion of the granite *massif* leads to the conclusion that other alluvial and residual deposits quite as productive as any of those worked at Moolyella may yet be discovered, and there is every reason to encourage systematic and judicious prospecting, for some enterprising prospector may yet be rewarded by closer examination. The stream tin owes its origin to the disintegration of the granitic rocks, which form the matrices of the lode tin, using this latter term to denote the ore occurring in the parent rock as distinct from the detrital product.

Although the country rock contains tin, yet the lode tin is at present unworked, nor do any of the deposits yet noticed appear to contain a sufficiently high percentage of black tin to be payable. It is by no means impossible, considering the large area of what may be called stanniferous country, that deposits may yet be found that can be profitably mined.

#### TIN-BEARING STREAMS.

The tin-bearing streams which, with their tributaries, are three in number, will be described in the following order :—

Prospector's Creek.

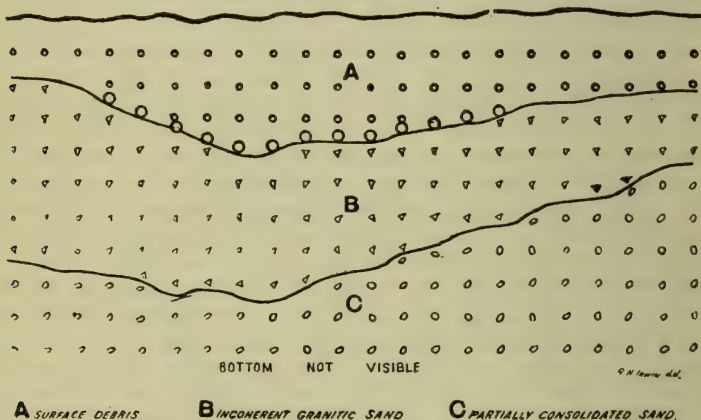
Meagher's Gully.

Moolyella Creek.

PROSPECTOR'S CREEK.—Prospector's Creek rises in the high ground originally embraced by M.L. 3, and after a generally west-

ward course of about 25 chains (during which it is joined by two short tributaries flowing from the north and one from the south) it trends gradually north-westerly for about a mile and a quarter, and extends far beyond the limits of the map. The upper portion of the course of the creek flows over fairly rugged granite hills, which have yielded a fair quantity of residual tin. What was originally M.L. 3 is situated near the head of Prospector's Creek, and, as may be seen by an inspection of the tin workings shown on the geological map, appears to have been extensively worked. The workings are very shallow, the tin ore lying within a very short distance of the surface. A hole about 8 or 9 feet deep has been sunk in a gully which flows from the hills at a point about 20 feet west from the westernmost angle of M.L. 2, the section in which is depicted in Fig. 25.

FIG. 25.



SECTION OF WASH IN PROSPECTOR'S CREEK M.L. 2 MOOLYELLA. 22

The granite bottom is not visible in the section. A well adjoining, 54 feet in depth, put down in the alluvial flat, reached the granite bottom at 8 feet from the surface. The situation of the well is evidently not in the channel of the old water-course.

The gutter in which the tin has been worked varies from 3 to 12 feet in width, and, so far as can be observed, nowhere exceeds 16 feet in depth. Prospector's Creek seems to have been extensively worked, and a good deal of tin obtained.

A tin-bearing dyke (?), consisting of a white rock, made up of quartz, felspar, a little mica (of a greenish hue), together with a few garnets, outcrops along the north side of the alluvial flat, traversing M.L. 2. This dyke contains coarse, angular tin, some pieces of which are nearly an inch in length. The dyke, which has been opened up for about 30 feet to a depth of about 4 feet, is about 2 feet in thickness, and has a general bearing of about 47



degrees. The dyke occurs in a fine-grained micaceous granite [5396]. The composition of the dyke [5397] is shown in the table on page 7. The felspar appears to be principally albite. About 40 tons of tin have been obtained from a pocket in the creek adjoining the dyke (?). Lower down the creek, at a point where it is crossed by a north and south reef, a considerable quantity of tin has been obtained, the quartz reef evidently acting as a bar which effectually prevented the detrital tin being washed down the river. The Independent M.L. 45, now abandoned, situated about 50 chains lower down the creek, has had a good deal of work done upon it, and about 15 tons of black tin, valued at £922, produced in 1900. It is almost impossible to arrive at the actual yield of the country drained by Prospector's Creek, owing to the way in which the returns have been kept.

MEAGHER'S GULLY.—Meagher's Gully lies about from 40 to 50 chains to the north of Prospector's Creek, and appears to have been extensively worked. The head of the gully rises to the north of M.L. 3, and flows northwards for about 50 chains parallel to a pegmatite dyke (?) which occupies the eastern bank of the gully. It is to the disintegration of this that the origin of the detrital tin from this portion of Meagher's Gully may be ascribed. This portion of the creek is embraced within the abandoned leases, M.Ls. 4 and 8. Near the northern boundary of M.L. 8 the gully makes a bend to the westward, and continues on this course for a distance of considerably over a mile, and extends far beyond the limits of the map. About 1 mile of the gully below M.L. 8 was at one time held under lease, M.Ls. 14, 16, 43, and 44. In the Old Sportsman lease, M.L. 46, upon which no work is at the present time being carried on, the tin wash is about 18 inches in thickness, and the payable portion averages about 8 to 10 inches in width; a thickness of about 3 feet of wash appears to be exceptional. The width of the alluvium in the lower reaches of the gully is as much as 10 chains, though the depth of detritus nowhere exceeds from 8 to 10 feet within the area of country examined.

*Table showing the Tin Yield of Meagher's Gully.*

Year.	Name of Lease.	Tin Ore Raised.	Value thereof.	Tin Ore Raised.	Value thereof.
		Tons.	£	Tons.	£
1899	Old Sportsman, M.L. 64	4·75	235	21·10	1195
1900	afterwards Sportsman, M.L. 16 .	12·35	740		
1901	„ „ .	4·00	220		
1900	Huntsman, M.Ls. 43, 44	8·00	502	32·50	1827
1901	„ „	19·50	1008		
1902	„ „	5·07	317		
Total . . . . .				53·60	3022

The preceding figures give the yield of Meagher's Gully so far as may be gleaned from the individual returns of the leases as published in the latest mining statistics. These figures, however, do not by any means give the actual yield of the country drained by the gully, but as they show the returns from certain properties of which a record has been kept, they are on that account worthy of record.

This table does not embrace the yield of M.Ls. 4, 8, and 14, which is included in the published mining statistics under the general heading of the Marble Bar Syndicate property.

**MOOLYELLA CREEK.**—Moolyella Creek is the most important yet worked in the district, and drains the largest area of country. For about 2 miles and a half of its course, the creek has been held one time or another under mineral lease, but at the present time these have all been abandoned. Moolyella Creek is formed by the junction of three principal tributaries, which flow into one another in the vicinity of the Universal Extended Lease, M.L. 12, some little distance to the south of the Government Well. These tributaries are Swan Gully, Universal Gully, and what is known as Tin Creek.

Swan Gully rises in the very high and rugged country embraced within what was originally the Victoria Lease, M.L. 6, and traverses the adjoining Swan Lease, from which the watercourse takes its name, thence it joins the main channel a few chains to the north-west of the old Lady Vosper Lease. The whole length of its course drains granite country of the usual type. So far as may be judged by the statistics it appears that this gully has been responsible for 59·5 tons of ore, valued at £3692. The ground on what was originally M.L. 7 traverses granite country, intersected by north and south pegmatite dykes of the usual type; many of these are too small to be shown on the map. In the upper portion of the creek there is from only 18 inches to 2 feet of cover, but this increases gradually as the channel is followed down.

In what may be called Universal Gully, two or three pegmatite veins, underlying at a low angle to the eastward, traverse the valley. At one point on M.L. 15 a vein about 3 feet in thickness crosses the bed of the stream and forms a low ledge in the channel over which the water falls about 3 or 4 feet, when the stream runs. About 9 tons of black tin were obtained from a pocket just below the fall. Several dry-blowers were at work just below these veins and in almost every case were obtaining good, coarse angular tin.

The Government Well at Moolyella is situated on the Reserve originally embraced by M.L. 25 and yields a fair supply of water, which issues from the decomposed granite underlying the alluvium at a shallow depth. To the west of the well is an almost flat vein of pegmatite, about 3 or 4 feet in thickness, trending generally north and south; this vein is in all probability continuous with that which first makes its appearance in the Universal South,

M.L. 50, about 70 chains southwards, near the head of the creek.

Five men were engaged at work on the A1 property, M.L. 23, at the date of my visit. A vertical shaft, 15 feet deep, bottomed after passing through 10 feet 6 inches of alluvium, on granite of the normal type. A good deal of water was obtained from the shaft; the water issued copiously from the decomposed granite below the bottom of the alluvium. The water was used for puddling. The average depth of the bottom in this creek for about a mile below the A1 is 8 feet and the width of the stanniferous wash varied from 15 to 60 feet.

Moolyella Creek has been practically worked from its source down to the Three Jacks M.L. 29.

The following table shows the yield of Moolyella Creek, so far as such can be ascertained from the official figures:—

*Table showing the Tin Yield of Moolyella Creek.*

Year.	Name of Lease.	Tin Ore Raised.	Value thereof.	Total Tin Ore Raised.	Total Value thereof.
		Tons.	£	Tons.	£
1899	Victoria M.L. 6 . . . . .	1·50	113	1·50	113
1899	Swan M.L. 5 . . . . .	8·50	575		
1900	„ . . . . .	17·50	1,142		
				26·00	1,717
1900	Lady Vosper M.L. 13 . . . . .	32·15	1,862	32·15	1,862
1900	Mandalay M.L. 11 . . . . .	1·10	71		
				1·10	71
1899	Universal M.Ls. 10, 12, 15, 18, 31	5·10	309	51·70	4,380
1900	„ . . . . .	46·60	4,071		
1899	O.K.M.Ls. 20, 21, 23 . . . . .	11·20	795	103·00	6,033
1900	„ . . . . .	39·05	2,486		
1901	„ . . . . .	52·75	2,752		
1900	Three Jacks M.L. 29 . . . . .	2·25	158	2·25	158
	Total . . . . .			217·70	14,334

This table does not include the yield from M.Ls. 7 and 9, which is embraced in the published mining statistics under the general heading of the Marble Bar Syndicate's property.

SUMMARY.—All the tin ore hitherto obtained from Moolyella is of detrital origin; the detrital tin has been derived from the disintegration of pegmatite veins traversing the granite, and is of distinctly local origin. The stream tin is practically worked out, whilst residual or surface tin may be found wherever the pegmatite veins are numerous.



The following table shows the yield of the Moolyella Field :—

*Synoptical Table showing the Yield of the Moolyella Tinfeld.*

Name of Creek, &c.	Tin Ore Raised.	Value thereof.
	Tons.	£
Prospector's Creek . . . . .	15·00	922
Meagher's Gully . . . . .	53·60	3,022
Moolyella Creek . . . . .	217·70	14,334
Not specified <sup>1</sup> . . . . .	569·28	37,885
Total . . . . .	855·58	56,163

From these figures, which have been taken from official sources, it appears that a considerable quantity of black tin has been produced from Moolyella. The modern alluviums and the residual deposits have been extensively worked and yielded the whole of the output. The richness however of these superficial deposits is no proof of exceptionally rich lodes or veins beneath, for owing to the difficulty with which tin is acted upon by atmospheric agencies extending over untold periods, it may by a process of natural concentration gradually accumulate in much greater quantities than it existed in the parent rock. Lode tin is known to occur in the field though the deposits have not been worked, owing presumably to their low grade; but deposits may yet be met with of sufficient richness to be remunerative, and there is every encouragement to search for them.

<sup>1</sup> This includes the yield of the different leases of the Marble Bar Syndicate property, which, owing to the way the returns have been supplied, it has not been possible to allocate to the different creeks.—A.G.M.

## APPENDIX I

*Descriptive Register of Specimens from the Pilbara Goldfield, 1903*

Registered No. of Specimen.	Registered No. of Microscopic Section.	Name.	Locality.
5395	497	Granite (decomposed)	Golden Granite Reef, Boodalyerri
5396	485	Granite . . . .	M.L. 2, Moolyella
5424	...	Decomposed Granite with quartz leaders	Golden Granite Lease, Boodalyerri
5426	484	Granite . . . .	Mosquito Creek
5384	439	Amygdaloidal Rhyolite (?)	Six miles above the North Pole, Shaw River
5392	443	Felsite (?) . . . .	Duffer's Creek, near Marble Bar
5397	486	Pegmatite . . . .	M.L. 2, Moolyella
5398	...	Coarse Pegmatite . . . .	M.L. 2, Moolyella
5404	444	Quartz Felsite . . . .	West side of Bamboo Creek, near Post Office, Bamboo
5417	480	Quartz Felsite . . . .	Elsie Road at Nullagine (De Grey) Crossing
5416	...	Felsite (?) . . . .	Elsie Road at Nullagine (De Grey) Crossing
5411	478	Granitic Schist . . . .	Eastern Mine, G.M.L. 451, Yandicoogina
5379	437	Diabase (?) . . . .	Trig. Station 6
5405	445	Dolerite (Diabase ?) . . . .	Bulletin Mine, G.M.L. 161, Bamboo Creek
5407	476	Greenstone . . . .	Cairn A, Yandicoogina
5425	483	Volcanic Ash (?) . . . .	Near Martin's (Boodalyerri), Little River
5377	435	Foliated Greenstone . . . .	Hills, near Box Soak
5375	{ 433 } { 434 }	Serpentine (?) . . . .	Hills, near Box Soak
5382	...	Weathered Schist . . . .	Lalla Rookh
5380	438	Quartzite . . . .	Gorge Camp, Strelley River
5387	...	Conglomerate . . . .	Mount Hogback, Shaw River
5388	442	Fine-grained Sandstone	Mount Hogback, Shaw River
5408	477	Fine-grained Sandstone	Yandicoogina
5419	481	Limestone . . . .	Near Mount Elsie, Elsie Creek
5420	482	Limestone . . . .	Carawine Pool, Oakover River
5422	...	Chalky (?) Limestone	Carawine Pool, Oakover River
5378	436	Laminated Chert (Quartzite)	Poonthanna Hill, Turner River
5381	...	Quartz . . . .	Bergamina, G.M.L. 606, Lalla Rookh
5383	...	Quartz . . . .	Alma North G.M.L. 602, Lalla Rookh
5385	440	Banded Chert . . . .	Ridge, Shaw River
5386	441	Chert . . . .	Ridge, Shaw River
5389	...	Green Quartz . . . .	Talga Talga
5390	...	Reef Quartz . . . .	Talga Talga
5391	...	Quartz . . . .	Main Reef, Talga Talga

*Descriptive Register of Specimens from the Pilbara Goldfield—continued*

Registered No. of Specimen.	Registered No. of Microscopic Section.	Name.	Locality.
5393	...	Jasper . . .	Near Marble Bar (with magnetite crystals)
5394	...	Jasper . . .	Shaw River
5399	...	Tin Ore . . .	Messrs. McDonald's lease, Moolyella
5400	...	Deep Ground Tin .	Moolyella
5401	...	Surface Tin . . .	Moolyella
5402	...	Tin Ore . . .	Moolyella
5403	...	Tin Ore . . .	Moolyella
5406	...	Iron Ore . . .	Just-in-Time, near Marble Bar
5409	...	Quartz . . .	Black Shepherd Reef, G.M.L. 544, Yandicoogina
5410	...	Quartz . . .	Eastern Reef, G.M.L. 451, Yandicoogina
5412	...	Quartz . . .	Granite Reef, Yandicoogina
5413	...	Quartz . . .	Lady Adelaide Reef, G.M.L. 249, Yandicoogina
5414	...	Quartz . . .	Invincible Reef, G.M.L. 557, Yandicoogina
5415	...	Quartz . . .	Uncle Tom Reef, G.M.L. 250, Yandicoogina
5418	...	Quartz . . .	Elsie Reef, G.M.L. 86, Mount Elsie
5421	...	Chert in Limestone .	Carawine Pool, Oakover River
5423	...	Chert in Limestone .	Carawine Pool, Oakover River
5427	...	Gold in Quartz . . .	Parnell North, G.M.L. 102, Mosquito Creek
5428	...	Gold in Quartz . . .	Off Chance, G.M.L. 128L, Mosquito Creek
5429	...	Gold in Quartz . . .	Barton Reef, G.M.L. 106, Middle Creek
5430	...	Quartz . . .	Barton Reef, G.M.L. 106, Middle Creek
5431	...	Copper-bearing schist	Strelley Reef, G.M.L. 84, Middle Creek



## DIVISION II

### FURTHER REPORT, 1904

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#### PART I.—DESCRIPTIVE GEOLOGY

Arriving at Port Hedland on the 30th of June in order to continue the examination of the different mining centres left untouched during the previous season, I travelled by coach as far as Marble Bar, and joined the camp, which was in charge of Mr. Talbot, on the 5th of July.

Leaving the camp at Duffer's Creek, we travelled northwards as far as the junction of Talga Creek and the Talga River. From the camp a conspicuous hill was observed 420 feet by aneroid in height and bearing 56 degrees from it. This hill forms the summit of a very long range extending northwards from the Talga Talga workings; it is composed of transmuted basic igneous rocks, intersected by laminated quartz veins. These foliated rocks dip westward at angles of from 40 to 60 degrees; associated with them are some green rocks, which weather very much like limestones; they are, however, identical with those basic igneous rocks, the original minerals of which are replaced by carbonates, so common in many parts of the district.

From this camp we travelled to a gorge known as Kitty's Gap, excavated in that laminated jaspideous quartzite, which extends from Doolena Gap to Bamboo. From camp to the Gap, the whole country traversed is greenstone and its derivatives, except for about a mile of granite, which in all probability is an off-shoot from the Moolyella mass.

After getting clear of the Gap, the northern face of the range was skirted as far as Coppin's Gap. The country at the foot of the northern face of the range exposes a gneissic granite, the strike of the foliation of which is parallel to that of the laminated quartzite which makes up the range.<sup>1</sup>

From Coppin's Gap we travelled northwards towards the point of a conspicuous range of hills which lay between us and Bamboo Creek. The highest summit of the hill rises to a considerable height above the plains, which are everywhere underlaid by granitic gneiss and allied rocks. The rocks forming the hill consist of volcanic agglomerate dipping at angles of about 20 to 30 degrees

<sup>1</sup> Bulletin No. 15, pp. 25, 26.

to the east, and passing beneath the sedimentary beds of what there are good reasons for believing to be the equivalents of the Nullagine Series. Associated with these agglomerates are greenish grey beds of either lava or ash. Travelling across to Bamboo Creek, strata on a somewhat higher horizon are traversed; they consist of coarse conglomerates, and fine-grained sandstones, some beds of the latter of which have been quarried to a limited extent. Some of these conglomerates and grits are traversed by vertical quartz veins, some of which are of considerable horizontal extent. The general strike of these "buck-looking" quartz veins is 16 degrees. From our camp at a fine pool of water near a boundary fence (? Coppin's) to the now all but deserted township of Bamboo, the road follows the edge of the top of volcanic beds of the Nullagine Series.

The country in the more immediate vicinity of this centre having been previously fully described<sup>1</sup> need not be repeated.

From Bamboo to the foot of Mount Edgar, *via* Jones' Well, the country is made up of granite of the Moolyella type, intersected by dykes of felsite and diabase in addition to quartz veins.

Mount Edgar, one of the most prominent landmarks in the vicinity, rises to a height of about 300 feet above the base, and consists of a bluish grey basic rock [5753] in the form of a dyke. In the vicinity of Mount Edgar, the staple formation of the district (granite) is traversed by two sets of felsite dykes, one set with a general strike of north 30 degrees east, and the other north 30 degrees west. Both of these sets of dykes are traversed almost at right angles by quartz reefs, in this respect they are somewhat analogous to the system of quartz reefs and dykes of the Charters Towers Goldfield in Queensland, with which I am familiar.

From Mount Edgar, we steered across country for Warrawoona, crossing *en route* a very conspicuous greenstone dyke, at the foot of the northern side of which the Talga River flows.

This dyke, which has a general bearing of 334 degrees and 163 degrees, rises to a considerable altitude above the plain, and forms a very conspicuous feature in the landscape. So far as can be seen, the dyke is vertical and attains a thickness of about 20 feet; it traverses granite country. Several other parallel dykes of a somewhat similar nature can be seen in the vicinity.

Between this point and Warrawoona, two other parallel dykes are crossed. The granite country ends about a mile or so north of Warrawoona, and gives place to those beds, a detailed description of which is given on a later page.

The mapping and examination of Warrawoona, having been completed, we struck camp and travelled in the direction of Yandi-coogina as far as Gum Well. The country between the camp and the well is underlaid with granite, which has a rude foliation, the general strike of which is parallel to that of the schists, which forms the high ground of the range, near the foot of which the

<sup>1</sup> Bulletin No. 15, pp. 26, 51-61.

main road traverses. At a point about two miles west of the well, a very prominent diabase dyke is crossed, in addition to two others of much smaller dimensions; the larger dyke in all probability represents the extension of the one crossed between Mount Edgar and Warrawoona. The large dyke near Gum Well makes a very prominent feature in the landscape, and can be followed by the eye across country for a considerable distance. A traverse on foot was made from Gum Well to the range, and at one spot the large coarse-grained diabase dyke was shifted for a horizontal distance of 120 feet west by a fault bearing 112 degrees. This fault is now occupied by a quartz reef. A parallel diabase dyke of smaller dimensions has also been subject to the same amount of western displacement.

From Gum Well, a conspicuous Gap in the main range can be observed. The position of the Gap is fixed by the following bearings:—Gum Well, 31 degrees 30; Mount Edgar, 41 degrees; Trig. Station G. 23, 276 degrees; and Horrigan's Peak, 302 degrees.

The Gap has been carved out of a bold quartz reef, which measures from 30 to 40 feet in width, and is of very considerable horizontal extent; for it has a length of about 4 or 5 miles in a direction of 118 degrees, and about a mile in the direction of 298 degrees. The quartz reef is evidently along a line of fault (?) which separates the granitic rocks from the Warrawoona Beds, which latter at this point occupy a width of about 2 miles. The large greenstone dyke previously alluded to abuts abruptly against the quartz reef of the Gap, but does not cross it. The Trig. Station G. 23 is formed of another large quartz reef, identical with that forming the Gap, and equally wide and persistent longitudinally. Both form remarkably pronounced features in the landscape.

The country between Gum Well and Yandicoogina is of granite intersected with numerous greenstone dykes.

From Yandicoogina, exigencies of travel rendered it necessary to travel as far as the De Grey (Nullagine) River *via* the main Elsie Road.<sup>1</sup> We camped on a creek, at an altitude of about 200 feet above Yandicoogina, which flowed in a general direction of north 70 degrees east. Advantage was taken of the short spell of daylight after arriving to examine the country in the vicinity. About 3 miles north 70 degrees east from camp was a conspicuous escarpment, the summit of which seemed to afford a good opportunity of examining the surrounding country, and a traverse was made in that direction.

On the eastern bank of the creek, upon which the camp was pitched, is a good exposure of sandstones and shales (Nullagine Series) dipping at 20 degrees in a direction north 30 degrees east and traversed by several small faults. Sandy beds cover the surface of the country as far as the foot of the escarpment.

The bed forming the summit of the hill is a thin bed of

<sup>1</sup> Bulletin No. 15, p. 27.



quartzose conglomerate, containing pebbles and fragments of those laminated quartz veins so conspicuous in other portions of the district. The general dip of these sedimentary rocks which must, as seen from the hilltop, occupy a large area of country, is in the direction 228 degrees at angles varying from 8 to 10 degrees.

Having reached the De Grey (Nullagine) River, it was followed to the junction of Cook's Creek. At a point about 6 or 7 miles in the river above the crossing of the Elsie Road, granite emerges from beneath the sedimentary rocks and occupies the country for some considerable distance. The granite is traversed by numerous quartz veins which have a general bearing of about 174 degrees.

Cook's Creek was followed up to the point at which it is joined by Mosquito Creek, passing the Black Range of the maps *en route*. The Black Range is a long razor-backed ridge of laminated quartz of the usual type. Having camped on Mosquito Creek some miles below the township, a visit was paid to the Parnell Mine.<sup>1</sup> The country between the camp and the township of Mosquito showed the staple formation to consist of highly-inclined grits, sandstones, and shales (or slates), with numerous quartz veins along the bedding planes (Mosquito Creek Beds).

In the vicinity of the lower (Mosquito Creek) well, two conspicuous rugged hills of granite (?) rise from amongst the sedimentary beds. From a distance these hills bear a remarkable resemblance to the granite hills of Mosquito township,<sup>2</sup> although the area these rocks occupy is not nearly so great as at the township.

From the camp at Mosquito Creek we travelled along the old 40-Mile Road to the crossing of Sandy Creek, which was followed down to its junction with the Nullagine River. The whole section down to the Nullagine River showed the staple formation to be of grits, shales, and conglomerates (Mosquito Creek Series) inclined at high angles. Where Middle Creek joins Sandy Creek is a vertical bed of fine-grained conglomerate.

The Nullagine (De Grey) River was followed up to the township of Nullagine, and the staple formation consisted of highly-inclined sedimentary rocks of the Mosquito Creek Series. On the western bank of the Nullagine River, at the junction of Taylor's Creek, is a large dyke of gabbro, striking about 230 degrees. The dyke, which in all probability has some intimate connection with that which makes such a prominent feature in the geology of the township of Nullagine, is about half a mile in width at this point.

Having completed the mapping of Nullagine, a full description of which is given on a later page, we followed the main road to Marble Bar, passing the almost deserted mining centre of Wyman's Well *en route*. The country round Wyman's Well, originally known

<sup>1</sup> Bulletin No. 15, p. 80.

<sup>2</sup> Loc. Cit., p. 78.

as Salgash, is identical in its geological features with Warrawoona, of which it merely forms the westward extension.

A 12-acre lease, the Phoenix G.M.L. 624, owned by Messrs. Anderson and party, and a three-men's quartz claim owned by Messrs. Swanson and Morris Bros., represent the mining activity prevailing.

Marble Bar was reached on the 29th of September.

## PART II.—DESCRIPTIONS OF INDIVIDUAL MINING CENTRES

### J.—NULLAGINE

*(With a Geological Sketch Map and Section, and a Plan of the Nullagine Conglomerates Gold Mines. Plates VIII. and IX.)*

The mining centre of Nullagine is situated 55 miles to the north-north-west of Marble Bar, upon the Nullagine River, about 90 miles above its junction with the Oakover; its relative position is shown on the Locality Map of the Pilbara Goldfield, which forms the frontispiece to this report.

Interest attaches to this district on account of the occurrence of gold in certain sedimentary rocks, which bear a close resemblance to the auriferous conglomerates of the Rand (South Africa), better known as the Banket deposits. These (Nullagine) auriferous conglomerates, which seem to form lenticular masses, occur in the basal members of the Nullagine Series<sup>1</sup> as developed in the ranges to the north-west of the township.

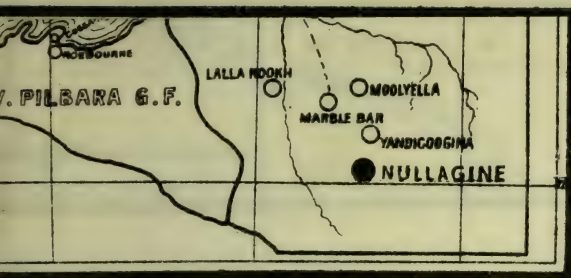
It being an important problem in economic geology to ascertain the extent, &c., of these auriferous conglomerates, as well as the quartz reefs in the underlying series of beds, a belt of country embracing what is, as at present understood, the productive area was mapped upon the scale of 20 chains per inch. The ground covered by this work comprises a belt of country about 4 miles in length and breadth, which is depicted upon the geological sketch map (Plate VIII.).

As by far the larger portion of this area was practically a blank upon any of the existing maps, operations had to be commenced by preparing a plan of the vicinity of the mines. This work was accomplished by the aid of a plane table and tape measure; it would, however, have been a decided advantage had time permitted of a contour map of the district being prepared. The local representatives of the British Exploration Company, the principal lease owners in the vicinity, courteously placed at my disposal their topographical plan of the Conglomerate Mines; a reduced copy of this, embodying some geological additions by myself, forms Plate IX.

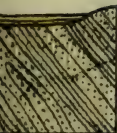
A comparison between this map and the 40-chain lithograph, L 76, issued by the Department of Mines, discloses the fact that

<sup>1</sup> Preliminary Report on the Geological Features and Mineral Resources of the Pilbara Goldfield, by A. Gibb Maitland. Geol. Surv. Bull. 15. Perth: By Authority, 1904, p. 10.





— Locality Plan —



ROCKS.

*R. H. Irwin del.*

HUDSON & KEARNS, LTD, LONDON







considerable violence had to be done to the position of the Nullagine River. On lithograph, L 76, it will be noticed that there are two Nullagine Rivers, the most northerly approximately parallel to the Marble Bar Telegraph Line, and the other skirting the northern boundary of the extinct leases 57L and 58L. The true course of the river is that shown on the geological map.

It is essential, in the public interest, that at any rate the principal water-courses, in mining districts especially, should be traversed and their position laid down on the published maps with such a degree of accuracy as the scale employed will admit. Tacheometric methods afford a reliable, cheap, and accurate method of this class of work being carried out expeditiously. A great deal of time and labour is involved in preparing topographical maps, upon which the areas of the different formations, the geological boundaries, the trend of the outcrops of the different ore deposits, &c., could be delineated, which could be much more profitably expended by a geologist in other directions.

In both its physical and geological aspects, the district falls naturally into two distinct portions, which lie respectively to the north-west and south-east of the Nullagine River.

The north-western portion is that occupied by the sandstones, grits, conglomerates, and interbedded volcanic rocks of the Nullagine Series. This series, which presents a plateau-like appearance, exhibits a bold escarpment when viewed from the south-east, and certain of the harder beds stand out in bold relief, presenting mural faces at different levels. The tableland has been carved out into deep canon-like gorges and ravines, of which Beaton's Creek, and the One Mile Creek, are typical examples. The course of many of these creeks and their tributaries appears to have been in the main determined by the trend of the system of master joints, by which the Nullagine Series has been intersected. An excellent example of this rectangular system of jointing occurs in Beaton's Creek about a mile and a half above its junction with the Nullagine River, just within the western border of the geological map.

The greater part of the country lying to the south-east is formed of an open rolling plain, the monotony of which is broken by a very conspicuous serrated ridge of gabbro (?). This dyke lies about 2 miles to the west of the township of Nullagine. The Nullagine River cuts through the ridge at a point about 3 miles below the township. This gabbro dyke rises to a considerable height above the level of the surrounding country and forms a very conspicuous feature in the landscape. This plain is underlaid by the rocks of the Mosquito Creek Series, which formation carries all the auriferous reefs yet worked in the district.

The whole of the country lies within the watershed of the Nullagine River and its tributaries; the two most important of which are Beaton's and Kadjebut Creeks.



## HISTORY

Very little appears to have been officially recorded of the early history of the Nullagine district. It seems, however, that the first discovery of gold at Nullagine was made by Mr. N. W. Cook, in the year 1886, as a reward for which he received, two years later, a sum of £250 from the Government.

The spot at which the original find was made lies at the western extremity of a long, narrow, laterite tableland, in close proximity to several quartz reefs; the position of this spot is indicated on the geological sketch map of Nullagine. (Plate VIII.)

The erection of a 10-head battery in 1895 at Nullagine, where the first crushing of 184 tons yielded 210 ozs. 16 dwts. of gold, appeared to have given a great impetus to mining, for the Warden of the field, writing in July of that year, reported: "Quite a boom in leasing has commenced."<sup>1</sup>

The following year, the Inspector of Mines for the Northern Goldfields stated: "At the Nullagine, quartz reefing (which has only been inaugurated during the past eighteen months) is making rapid advances, crushings having yielded from 2 ozs. to 8 ozs. per ton, while the acquisition of a large area of conglomerate holdings by an English company marks a new era in the history of the district."<sup>2</sup>

The progress of Nullagine during the year 1897 is thus alluded to by the Warden in his Annual Report to the Minister for Mines: "Besides alluvial digging and quartz reefing, gold is obtained from conglomerate lodes with payable results. There is one 10-head battery, and two more are in course of erection. Water is obtained at an average depth of 50 feet. The yield of gold for the year is 982 ozs. There are regular consignments of alluvial gold from Nullagine, of which I have no record; but, from information obtained from the business people, I should say that, at the lowest estimate, these would amount to 600 ozs. per annum."<sup>3</sup>

Writing on the advances made on the Pilbara Goldfield during 1898, the Warden thus alludes to the progress of Nullagine: "The North-West Australian Goldfield, Ltd., at Nullagine, are showing their confidence in their conglomerate lodes by supplementing their crushing machinery and laying down tramways, and thus, by working on a large scale, endeavour to decrease expense and make their properties pay."<sup>4</sup>

No mention is made of the progress of Nullagine during 1899, 1900, and 1901 in the reports of the Warden, as published in the

<sup>1</sup> Supplementary Report on the Department of Mines, 1st October 1895. Perth: By Authority, 1895, p. 4.

<sup>2</sup> Pilbara and West Pilbara Goldfields, 1896. S. J. Becher. Report of the Department of Mines for the Year 1896. Perth: By Authority, 1897, p. 36.

<sup>3</sup> Report of the Department of Mines for the Year 1897. Perth: By Authority, 1898, p. 23.

<sup>4</sup> Report of the Department of Mines for the Year 1898. Perth: By Authority, 1899, p. 19.

annual reports of the Mines Department ; for 1902, however, it is stated : " A large amount of good and useful development work is being done in the Nullagine District, where a further 10-head of stamps is being erected on the British Exploration and Development Company's property, which, when completed, will enable them to run 15-head, and for which purpose they are carrying out a water scheme which, when completed, will bring water a distance  $1\frac{1}{4}$  miles from the river to the mine. Later on another 20-head is proposed to be erected." <sup>1</sup>

The year 1903 was a very quiet one in Nullagine in so far as any mining was concerned, and no mention is made of its progress in the Annual Departmental Report for that period.

### GENERAL GEOLOGY

The following represents in tabular form the geological formations in the district embraced by the area of the map. The stratified rocks are arranged in geological sequence :—

Alluvial deposits.

Laterite.

Nullagine Series—Quartzites, grits, conglomerates, and interbedded igneous rocks.  
Unconformity.

Mosquito Creek beds—Sandstones, fine conglomerates and shales.  
Greenstone dykes.

### Alluvial Deposits

The banks of the Nullagine River and its tributaries are skirted by a variable width of alluvium, the full extent of which has been shown on the geological map. The greatest width attained by the alluvium is about 50 chains, but in no case does it reach any great thickness.

The south-eastern banks of the Nullagine River show a considerable extent of alluvium at a much greater elevation than that of the present water-courses. This is depicted in Fig. 26. This section shows the remains of an older alluvium laid down at a time when the Nullagine River flowed at a slightly higher level than now.

Writing in the year 1890, Mr. H. P. Woodward says, with reference to the alluvial deposits of Nullagine, that <sup>2</sup> :—

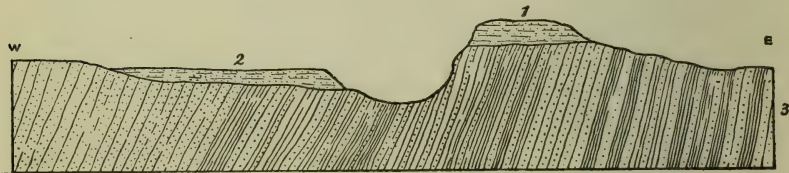
" Three classes occur ; 1st, the alluvium of existing creeks ; 2nd, the alluvium of older creek beds, but in conjunction with the present streams ; 3rd, older alluvial deposits or deep leads bearing no relation to existing streams or configuration of the country. . . . The older alluvial deposits are found in the river flats, where the auriferous gutters are crossed and recrossed by the present streams. The sinking here is about 10 feet, and very hard work, owing to the

<sup>1</sup> Report of the Department of Mines for the Year, 1902. Perth : By Authority, 1903, p. 44.

<sup>2</sup> Annual General Report of the Government Geologist for the Year 1890. Perth : By Authority, 1891, p. 25.

fact that the deposits that overlay the dirt are cemented masses of quartz and boulders of other hard rocks. . . . The deep leads are cut across by the present valleys, and can be traced from hill to hill. Here the sinking is very variable in depth, the whole gutter in some places appearing on the side of a cliff where the work merely consists in driving, while in other places shafts up to 60 feet or 70 feet have to be sunk to work the same lead. Up to the present only one of these leads has been discovered, but there cannot be the least doubt that more will be found when the small hills between the conglomerate range and the creek are thoroughly prospected. All three of these deposits are very rich, but no one

FIG. 26.



SECTION ACROSS THE NULLAGINE RIVER NEAR TOWNSITE. PILBARA G.F.

1. OLDER ALLUVIUM. 2. NEWER ALLUVIUM. 3. SANDSTONES, GRITS AND SHALES.

can estimate the quantity of gold with any degree of accuracy, as so much leaves the colony without ever being reported ; but there is no doubt that more has been taken from this field than from any other in the colony."

It is not quite clear from what can at present be seen in any of the sections exposed in the neighbourhood of Nullagine, that what are described above as "deep leads" are such ; the impression left upon my mind is that they merely represent weathered outliers of the basal members of the Nullagine Series.

Table showing the Yield of the Alluvial and Superficial Deposits of the Nullagine District generally.

Year.	Gold.	
	Gross Ozs.	Fine Ozs.
1897 . . . . .	No data.	
1898 . . . . .	1,000·00	928·98
1899 . . . . .	729·79	679·18
1900 . . . . .	27·00	25·86
1901 . . . . .	831·02	782·49
1902 . . . . .	390·67	373·81
1903 . . . . .	288·30	272·46
1904 . . . . .	403·24	378·06
Total . . . . .	3,670·02	3,440·48



### Laterite

A very noticeable geological feature of the area, is the occurrence of several isolated tablelands of laterite; the area which these occupy has been accurately delineated upon the map of the district. One very important feature which the map, owing to the lack of contour lines, fails to bring out, is the uniform level at which this laterite invariably occurs.

The most conspicuous tableland is that which lies to the south-west of the township, and about a quarter of a mile west of the river bank. The tableland has a length of about a mile and a quarter, and an average width of about 10 chains; it presents a steep bluff, several feet in height, which extends with scarcely any interruption all round the plateau.

This tableland is breached by that tributary of the river which flows into it near Suburban Water Right No. 5. The laterite continues from this point as a narrow strip far beyond the limits of the map. Three other outliers occur to the north of Beaton's Creek, the most conspicuous being that which lies adjacent to the township of Nullagine.

An inspection of the geological map demonstrates that the laterite traverses successively all the geological formations, with the single exception of the modern alluvium.

In its lithological characters the deposit presents all gradations, from ferruginous claystone to pure limonite; the rock itself is very porous, and weathers readily into caverns and cavities of all sizes; in some places the surface of the rock is covered with a glaze of hydrated oxide of iron. When seen in section, it is noticed that the laterite passes by insensible gradations into the underlying strata without any sharp line of demarcation.

Mr. Woodward refers to what is evidently the laterite series as follows: "Another line of flat-topped hills, but lower, extends along the side of the creek, but these are of much more modern formation,<sup>1</sup> and it is in these that the deep leads are met with. The beds which form these hills rest directly upon the indurated slates<sup>2</sup> and pipeclay, soft white sandstone, gypsum, and boulder beds. The wash is often very ferruginous and hard, necessitating crushing. The whole of these beds are capped by a ferruginous sandstone containing large quantities of fossil wood."<sup>3</sup>

It may be noted in this connection that I saw nothing which could be described as fossil wood anywhere in the series, as exposed in the vicinity of Nullagine; this, however, may possibly be due to the fact that at the time the district was visited work was in full swing, and Mr. Woodward may have had better opportunities for observation than were open to me.

<sup>1</sup> The beds of the Nullagine Series.—A.G.M.

<sup>2</sup> The Mosquito Creek Beds.

<sup>3</sup> *Ibid.*, p. 35.

## The Nullagine Series

### *Sedimentary Rocks.*

The Nullagine Series is largely developed in the Pilbara Gold-field, and consists of a great thickness of sandstones, grits, conglomerates, and limestones, some of which are magnesian, together with a series of lavas and ashes and agglomerates of as yet unascertained thickness.

The formation, the base of which is rarely seen, makes a prominent feature in the landscape of the district, and plays a very important part in the geology of the north-west, in addition to being of some economic value by reason of the basal members of the series having been proved to be auriferous in at least two localities many miles apart.

*Previous reference to the Series.*—In Bulletin 15 full descriptions have been given of the different sections which illustrate the relationship of the Nullagine Series to those beneath,<sup>1</sup> and therefore need not be repeated.

Mr. H. P. Woodward, in the year 1890, makes the first brief official mention of the auriferous conglomerate of Nullagine in the following terms: "To the west of this field are hills of nearly horizontally-bedded conglomerate rocks, probably of Devonian Age, in which reef gold occurs in small veins of quartz and ironstone, which follow and indeed fill in all interstices between the larger boulders. They are very rich in places, in fact so rich that it pays to 'dolly,' and the gold in the flat close by is evidently derived from these veins. This deposit is of very great interest, as nothing like it has before been found, for the gold, although occurring in an alluvial deposit, is reef gold and not alluvial, for it has been deposited subsequently to the formation of these boulder beds."<sup>2</sup>

On a later page of the same report, in the description of the country traversed from Geraldton to Nullagine, Mr. Woodward gives a few particulars with reference to the auriferous conglomerate and its relation to the older strata in the following terms: "In this conglomerate the gold is alluvial in character, but it is true reef gold, being deposited there subsequently to the deposition of the boulders between which it has been infilled with silica and iron, probably by thermal action. These beds dip at an angle of 12 degrees to the north-west. They vary greatly in character from quartzite to boulder conglomerate, but it is only in the ferruginous beds that the gold is found. This formation is probably of Devonian Age, resting unconformably upon the edges of the clay slates and quartzite conglomerate beds with quartz reefs of the metamorphic series."<sup>3</sup>

The latter portion of this description shows that the violent

<sup>1</sup> Pp. 18, 20, 21, 22, 23, 24, 25, 27, 28, 30 and 31.

<sup>2</sup> Annual Report of the Government Geologist for the Year 1890. Perth: By Authority, 1891, pp. 25-6.

<sup>3</sup> *Ibid.*, pp. 34-5.

unconformability separating the beds of the Nullagine Series from those of the Mosquito Creek beds was at least recognised, though not emphasised, by Mr. Woodward fifteen years ago.

Writing in the year 1895, the Acting Inspector of Mines, Mr. S. J. Becher, informed the Minister for Mines that: "Nullagine, one of the oldest and best districts of the whole field (Pilbara Goldfield), lies about 80 miles south-east of Marble Bar. Geologically, it is perhaps unique. The general character of the country is that of table-topped hills about 200 feet high, intersected by deep ravines, gullies, and valleys, widening out into flats and plains in all directions. In the immediate neighbourhood of the township the main characteristic features are: First and centrally, flat-topped hills having ironstone formations, as 'crust,' overlying decomposed conglomerate matter; secondly, hills more rounded on top consisting of red and white cement and conglomerate deposits of varying thickness, some of the waterworn quartz being quite boulders in size. The conglomerate contains a great quantity of ferruginous matter, and this apparently carries most of the gold, which occurs in a fine state."

"The central hills seem to have been the result of denudation and decomposition of the material of the surrounding conglomerate and other formations. For the past six or seven years there has been a steady output of alluvial gold from this field. Every gully has been systematically worked, the wash being screened and then carted down to the pool in the river for puddling and washing. The screenings, &c., have even been reworked at a profit by dry-blowers. It was noticed that the 'runs' of gold extended up the hillsides from out of the creeks and gullies. These runs were followed up the surface rubble for a few inches in depth, being all put through the dry-blowing machines, until the run ceased, when it was found that the original source of the gold was a seam or perhaps a big lode of conglomerate, whose outcrop was on the contour line where the run of gold ceased extending up the hillside. Though alluvial work is still carried on, more attention is now paid to the conglomerate lodes, which are being extensively worked and put through the battery with payable results."

"Of late, too, some very rich reefs have been found a few miles out, in what is locally known as the 'claypan' country. Crushing from the outcrops and superficial works on these reefs are returning from 2 to 4 ozs. per ton, and their prospects of permanency in depth are, it is said, good."

"The conglomerate lodes have attracted the attention of English capitalists, and there will soon be extensive works thereon in operation. . . ."<sup>1</sup>

In 1898, Mr. S. J. Becher describes the conglomerates of Nullagine in the following terms: "In the immediate vicinity of Nullagine township or mining camp, range upon range of con-

<sup>1</sup> Report of the Department of Mines for the Year 1895, Appendix 5. Perth: By Authority, 1896, p. 29.



glomerate hills lie to the north-west. . . . The course of the river . . . follows the outskirts of the conglomerate country, keeping on the farther side of the slate country and its quartz reefs, and forms a marked line of division, as it were, between the characteristic topographical features of the district. . . . Coming then to the conglomerate ranges, which average in height about 100 to 150 feet above the level of the river flat, we find that the hills in the forefront, upon which the chief mine workings are at present situated, appear to be mostly round-backed and strewn with rounded boulders and pebbles. On closer examination, one finds that they consist of bed upon bed of conglomerate, merging into intermediate layers of kaolin. The beds dip universally to the north-west, and strike north-east and south-west. The dip is flat, averaging perhaps 15 degrees. Therefore as one approaches from the south-east the hillsides exhibit longitudinal sections of the country, and in some cross gorges very complete studies may be made of cross-sections; whilst, where the rounded weathered hillsides slope to the flat, one may notice somewhat regular lines of round boulders and pebbles roughly marking the outcrops of the conglomerate beds. By these indications, and also by following up the runs of alluvial gold until they stopped all along certain horizontal lines, the auriferous conglomerates were originally located and worked by prospectors by means of drifts and tunnels."

"Some of the conglomerate beds contain boulders up to 3 or 4 feet in diameter, while others carry nothing bigger than a man's head. These boulders consist of rounded masses of fragments of quartz, trap rocks, and other conglomerates. A peculiar feature about the shape of these is that they are very often somewhat flattened like curling stones. This flattened shape might suggest glacial action, but the writer saw no striæ. These have, the writer understands, proved to be less auriferous than the other beds whose component particles are small. The best gold seems to be obtained from ferruginous veins. The ore now being crushed by the mining companies varies in value, the writer believes, from 10 dwts. to 2 ozs. per ton, the treatment being by battery and amalgamation alone. The gold is worth £3, 17s. 6d. to £4 per ounce. At the time of the writer's visit, in the year 1896, only the decomposed portion of the beds had been worked, but he is given to understand that a vertical shaft has since cut a bed in depth below the zone of decomposition, and that the character of the rock is a very hard greenstone conglomerate, carrying much iron pyrites, samples of which have yielded returns by assay up to 13 dwts. per ton."

"Behind these round-backed series of hills, to the westward, the topographical features vary again, and the conglomerate ranges assume an appearance of being terraced, the reason of which becomes evident upon examination. Following up into these ranges an affluent of what is known as the main creek, one enters a gorge

Fig. 27.



*Photo. : S. J. Becher.*

Beaton's Pool, showing the Conglomerates and Interbedded Ashes, Nullagine.





with precipitous sides rising to 50 feet in height, and here a very fine cross section of the country may be examined. Here it may be seen that, interbedded conformably with the beds of conglomerate, there are indurated slates and grits. The former, where long exposed to the action of the atmosphere and water, split off into flags."

"Compared with the above-mentioned series, little or no decomposition has taken place beyond surface-weathering, which accounts probably for the fact that no free gold (to speak of) has been obtained in the gullies, and that the terraced series is not at present recognised as auriferous. Time may prove this. The terracing is due to the unequal effect of weathering on the exposed longitudinal edges of these otherwise undecomposed beds of varying durability."

"As to the age and origin of these interesting Nullagine beds, nothing definite is yet known. . . ."<sup>1</sup>

Professor David, writing in 1902 on the Permo-Carboniferous glaciation of Western Australia: "There is . . . in my possession a photograph (Fig. 5) taken by the late Mr. Becher of the Geological Survey of Western Australia, of a remarkable conglomerate at Nullagine, Pilbara, Western Australia, which so closely resembles in general appearance the Cambrian glacial beds of South Australia as at once to suggest a possible glacial origin for the West Australian beds. They are also associated with a very finely laminated shaly altered rock, not unlike the Tapley's Hill shales, which overlie the Cambrian (?) glacial beds of South Australia. These Nullagine beds are probably of older palæozoic age (? pre-Cambrian), and should well repay further investigation."<sup>2</sup>

The finely-banded rock, to which Professor David thus alludes, is probably either one of those lavas or ashes, which lie near the base of the series and are well exposed in Beaton's Creek, and the Nullagine River itself.

In the more immediate vicinity of Nullagine there are several cliff sections which show the mutual relationship of the various members of the series. (Fig. 27.)

In Beaton's Creek, a tributary of the Nullagine River, which it joins at the foot of McFie Street, is a very good section, showing the relation of the interbedded character of the volcanic rocks, forming the basal members of the series.

A portion of this section is shown in Fig. 28.

The cliffs near Beaton's Pool expose two beds of ash dipping to the westward at an angle of 17 degrees from the horizon. The uppermost bed attains a thickness of 5 feet 6 inches, and is separated by 6 feet of conglomerate from another ash bed 12 feet thick. In the geological map, owing to the smallness of the

<sup>1</sup> The Nullagine District, Pilbara Goldfield, Western Australia. Trans. Inst. Min. Engineers (Newcastle-upon-Tyne), 1898. Vol. xvi., Pt. 1, pp. 44-52.

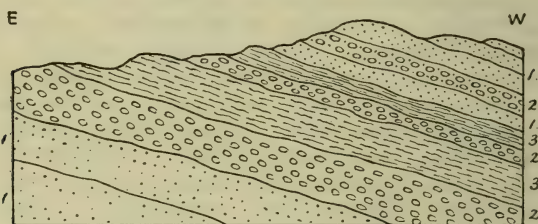
<sup>2</sup> Report of the Glacial Committee. Austral. Assoc. for the Adv. of Sci., vol. ix., 1902, p. 201.

scale, this deposit has been treated as one bed. The mapping shows that the bed is merely an attenuated lenticular patch of no very great horizontal extent.

A little distance below the pool is another much thinner bed of somewhat greater horizontal extent; it can be followed northwards as far as the southern angle of G.M.L. 2L (216), "The Trinity," where it is cut off by the fault which traverses this portion of the district. A good section of the ash is to be seen in the gully to the south of "The Trinity," at a considerable altitude above the level of Beaton's Pool, for the strata rise very rapidly in this direction.

The uppermost bed of ash [5796], which forms a fall over which the waters of the creek drop into Beaton's Pool, extends about 50 chains to the northward, where it also is truncated by the fault previously alluded to. In the vicinity of the fault, the bed has a slightly increased dip of 20 degrees to the west. A small

FIG. 28.



SECTION AT BEATON'S POOL PILBARA G.F.

1 SANDSTONE. 2 CONGLOMERATE. 3 ASH.

attenuated portion of it is to be seen on the downthrow side of the fault near the head of one of the branches of Beaton's Creek. It is possibly this bed which occupies the topmost stratum of the synclinal trough occurring on M.L. 1L. There is, however, no great thickness of ash in this section, the bed evidently thinning out rapidly in this direction.

A traverse up Beaton's Creek for about a mile or so above the pool shows the beds overlying the ashes to consist of conglomerates [5797] and grits disposed in a series of gentle folds, with dips varying from 5 to 8 degrees from the horizontal. The cliffs rise to considerable elevations above either bank of the creek, and show good sections of the strata. The beds are traversed by a series of rectangular joints which have proved to be the dominant factor in determining the general direction of the watercourse.

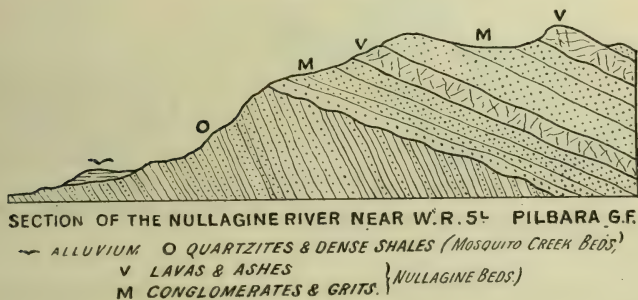
An important section is to be seen on the southern bank of the Nullagine River at a point about 40 chains south-west of Suburban W.R. 5L, which discloses the violent unconformability separating the Nullagine from the underlying series (Fig. 29).

The basal member of the Nullagine Beds in this section consists of a few feet of grit and conglomerate, overlaid by about 3 feet of ash, the whole dipping at an angle of about 18 degrees to the south-west. These rest upon the upturned edges of the quartzites and dense shales forming the Mosquito Creek Beds, which latter dip at angles averaging about 70 degrees in a south-west direction.

Some distance higher up the river the conglomerates and grits of the Nullagine Beds are overlaid by acidic lava [5795]. These volcanic beds occupy the country as far as Wild Dog Camp, Res. 3328,<sup>1</sup> about 16 miles above the township, and entirely conceal the sedimentary rocks beneath. In the neighbourhood of Wild Dog, the lavas are somewhat amygdaloidal [5808]. In certain portions of the district, the irregularities of the old surface upon which the beds were laid down is such that the volcanic beds often overlap the older rocks.

About four and a half miles eastward, the volcanic rocks rest

FIG. 29.



directly upon granite, at an altitude of about 200 feet above the well at Wild Dog Camp, the sedimentary rocks beneath being absent. This granite country is traversed by several quartz reefs. A very prominent reef, having a general trend of 248 and 63 degrees with a horizontal extent of a few miles, does not appear to be a fissure vein, as generally understood, but merely a gradual replacement of the surrounding granite by silica along a main line of weakness.

The bedded lavas, which are sometimes vesicular, were followed westwards some miles beyond Trig. Station G 13, on the head waters of the Coongan River; and from their mode of occurrence in the field, it is evident that they rest in this locality upon a very uneven surface.

No opportunity presented itself of tracing the boundary of the Nullagine Series to the south of Wild Dog Camp, but so far as may be judged from Mr. Woodward's descriptions, the formation would

<sup>1</sup> Lands Department Lithograph 16 G.



appear to extend to a point a few miles to the westward of Bamboo Spring (Res. 1927) on the head waters of the Shaw River, for it is stated "the rocks (near Bamboo Spring) are quartzite and basalt, with veins of chalcedony and inferior opals; the chalcedonies are often finely banded, and should be of considerable commercial value, as they can be obtained in large blocks."<sup>1</sup>

From a personal knowledge of the country, I have very little doubt as to the identity of the strata to which Mr. Woodward refers with those already described.

The road from Nullagine to Wild Dog Spring passes, after getting clear of the town, near Kadjebut Spring, a watering-place on the creek of that name. In the vicinity of the spring there are several sections which give a fair idea of the relation existing between the various rock formations.

The Fig. 30 gives a generalised section of the country in the vicinity of what is known as the rock hole, near Kadjebut Spring.

On the western side of the large dyke, which at this point

FIG. 30.



SECTION IN THE VICINITY OF KADJEBUT SPRING. PILBARA G.F.

V. LAVA & ASHES } NULLAGINE SERIES    O. SANDSTONES, CONGLOMERATES & SHALES. MOSQUITO C<sup>k</sup> SERIES  
M. GRITS & CONGLOMERATE }    N. GABBRO.

attains a considerable thickness, the Nullagine Series is represented practically by lavas and ashes, with a thin bed of conglomerate underlying. The beds rest with a violent unconformity upon the upturned edges of the Mosquito Creek Series. The Nullagine conglomerates and grits abut directly against the dyke along its eastern wall. So far as can be seen, there is no evidence of alteration of the sandstone and conglomerate anywhere along the line of contact between them and the dyke, nor so far as I could detect were there any pebbles of the gabbro contained in the conglomerate. The evidence so far as it goes seems to point to the junction between the two formations being in this locality a line of fault. In no place, however, did this dyke pierce the Nullagine conglomerates, though some miles northward in the vicinity of the One-mile Creek, a narrow dyke of a similar character does rise to the level of the Nullagine Series, and can be followed across country north-west and south-east traversing in turn each individual bed.

The basal conglomerate is made up of rounded, ellipsoidal, or subangular fragments of the strata forming the older underlying

<sup>1</sup> Loc. cit., p. 34.



Fig. 31.



*Photo. : S. J. Becher.*

A portion of the Auriferous Conglomerate, Nullagine.



series (the Mosquito Creek Beds). These often include pieces which may reach a length of 3 or 4 feet, but the bands containing the larger fragments are merely local. Figure 31 shows a portion of this conglomerate at the entrance to one of the mine workings. The conglomerate consists chiefly of fragments of the existing conglomerates, cherts, grits, and shales; reef quartz, identical in character with that forming the auriferous deposits in the underlying strata, being a very common constituent. The pebbles are embedded in a matrix, which is principally sandy, though sometimes aluminous.

Some portions of the conglomerate contain flattened and striated pebbles [5805] of fine-grained sandstone and sandy shales, identical in character with the beds of the Mosquito Creek Series; to these striated pebbles a glacial origin has been assigned by the late Mr. S. J. Becher, and subsequently by Professor David. These pebbles, however, would, in the light of the evidence now available, seem to have had their striation induced previous to their taking part in the formation of the Nullagine Series. The beds upon which the series rest with a violent unconformability, and to the denudation of which the pebbles owe their origin, having been subject to intense mechanical deformation, it would only be natural to find slickensided fragments and pebbles in the newer rocks. Earth movements have caused the Nullagine Beds to be thrown into a series of undulatory folds, well shown in the geological map and section, but the deformation thus engendered has not been of sufficient intensity to cause any striation of the component pebbles.

The conglomerates or consolidated shingles are of distinctly sedimentary origin, and owe their occurrence to the disintegration of pre-existing strata, which will be fully described on a later page. From the angularity of many of the pebbles, which make up the mass of the basal members of the series, it may be reasonably inferred that the coast-line which furnished them was not far distant. No outliers of the series occur anywhere in the vicinity of the country embraced by the geological map of Nullagine. From this fact and the angularity of many of the conglomerate pebbles it may be inferred that the present boundary of the series approximately marks the original shore-line. The evidence available from a careful study of the district over which the series extends, shows that the surface upon which the beds were laid down was extremely irregular. This irregularity was particularly apparently in the neighbourhood in which the basal shingles have been mined. The auriferous strata occur through a thickness of about 300 feet of grits, sandstones, and conglomerate, forming the lowest portion of the series: those portions of the strata which have been proved to be gold-bearing are those which are largely impregnated with the oxides or sulphides of iron, and which lie between the fault north of Beaton's Creek and the greenstone dyke (possibly along a fault-line also) crossing the One-mile Creek

in the vicinity of Mineral Lease 5L. As may be seen by the table below, the gold contents of the conglomerates are small, not amounting to more than at the rate of .62 ozs. for the total tonnage crushed since mining first commenced.

*Table showing the Yield of the Auriferous Conglomerates of the Nullagine Series.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . . . .	357·60	434·70	1·21
1897 . . . . .	246·00	228·00	·92
1898 . . . . .	893·00	1,001·20	1·12
1899 . . . . .	753·40	533·35	·70
1900 . . . . .	382·00	149·90	·31
1901 . . . . .	1,458·00	647·53	·44
1902 . . . . .	300·00	128·51	·42
1903 . . . . .	777·00	94·10	·12
1904 . . . . .	<i>Nil.</i>	<i>Nil.</i>	...
Total . . . . .	5,167·00	3,217·29	·62

*Igneous Rocks associated with the Series.*

From the geological maps and the descriptions given in this and Bulletin 15, it will be seen that a great series of bedded lavas, ashes, and agglomerates form an integral, and no small portion of the series as developed in different portions of Pilbara Goldfield.

Wherever these beds have been examined it has been invariably found that they consist of acidic lavas, the composition of some of these [5392, 5404, 5384], which may be regarded as typical of the series, have already been published in Bulletin 15 and need not be repeated.

The greater mass of the rocks consist of separate lava-flows, each of no very great thickness. Some of the lavas are distinctly amygdaloidal, the cavities being filled with chalcedony.

Some of the finer-grained ashy beds [5796] differ very little in general appearance from many of the banded lavas, with which they are associated, but their distinctly fragmental character can readily be made out by the microscope, and in some cases with the aid of a pocket lens.

So far no evidence has been obtained which would throw any light upon the sources from which the lavas emanated.

In the neighbourhood of Coppin's Gap, the volcanic rocks of the Nullagine Beds are represented by coarse agglomerate, dipping at angles of about 20 to 30 degrees to the east, and passing beneath the sedimentary rocks of the series. Associated with these are beds of greenish grey lava. The sedimentary rocks of the series, which occur at a somewhat higher horizon, consist of coarse con-

glomerate and fine-grained sandstone. The hills of conglomerate rise to considerable heights above the surrounding plains, which in this particular locality are underlaid by granitic gneiss and allied rocks.

On the Coongan River, some distance below the township of Marble Bar, a mass of volcanic agglomerate forms a very conspicuous irregular-shaped hill, which presented every appearance of being the focus from which the surrounding lavas emanated.

There are several acidic dykes visible in different portions of the district, which may possibly represent another phase of that volcanic activity which was rife.

In the neighbourhood of the town site of Nullagine, a mass of quartz felsite [5798] was met with in the well on W.R. 2L. This well has been carried down to a vertical depth of 108 feet, through quartz felsite the whole way. This rock, the position of which is shown on the map of the Nullagine Conglomerates Gold Mines forming Plate IX., makes its appearance on the western bank of the creek, and rises to about the level of the floor of the battery site, where it seems to have diffused itself through a portion of the coarse auriferous conglomerate forming the base of the formation in this locality. The quartz felsite is very much decomposed, the alteration extending as far down as the bottom of the well, which is the deepest point at which it has been pierced. Examined under the microscope, the rock is found to consist of quartz and plagioclase, set in a partially devitrified matrix.

### *Age.*

The recognition of the position of the Nullagine Beds in the stratigraphical succession is a point of considerable importance; the absence of fossils throughout the series, wherever it has yet been studied, however, renders correlation extremely difficult.

The earliest investigator of the district, Mr. H. P. Woodward,<sup>1</sup> assigned a Devonian Age to the series, though the evidence does not seem to be conclusive. The next observer, Mr. S. J. Becher, writes that of "the age and origin of these interesting Nullagine Beds nothing definite is known."<sup>2</sup>

Professor David infers that the beds are "probably of older Palæozoic Age (? pre-Cambrian), and should well repay further investigation."<sup>3</sup>

The limestones of the series having yielded no fossils, petrographical resemblance seems to be the only method by which any clue can, in the present state of our knowledge of the series, be arrived at with respect to its age.

<sup>1</sup> Annual Report of the Government Geologist for the Year 1890. Perth: By Authority, 1891, pp. 25 and 26.

<sup>2</sup> The Nullagine District, Pilbara Goldfield, Western Australia. Trans. Inst. Mining Engineers (Newcastle-on-Tyne), 1898. Vol. xvi., Pt. 1, pp. 44-52.

<sup>3</sup> Report of the Glacial Committee. Austral. Assoc. for the Adv. Sci. Vol. ix., 1902, p. 201.



In a previous report<sup>1</sup> the difficulty of correlating the Nullagine Beds with any of the formations described in the official publications on the geology of Western Australia was fully set out, and the lithological resemblance to the quartzites, &c., of the King Leopold Range, in Kimberley, was emphasised. If this petrographical resemblance should prove to possess greater significance than at present appears, the Cambrian Age of the Nullagine Series would seem to have strong claims for consideration.

The Nullagine Beds have a very wide distribution in the North-West Division, and the Volcanic Series would seem to occupy a large area of country in the southern portion of the district. It may be noted that, in a bore put down by the Government at Onslow, near the mouth of the Ashburton River, to a depth of 1729 feet, there was passed through a thin bed of a volcanic rock ("basalt" of the bore journal) identical in its characters with some of those igneous rocks forming part of the Nullagine Beds as developed elsewhere. It may thus be that these strata were pierced in the lower portion of the Onslow bore-hole.

Undoubted Permo-Carboniferous fossiliferous rocks are known to occupy a large area of country in the watersheds of the Gascoyne, the Minilya, and the Lyndon Rivers; hence an examination of the (geologically unknown) country lying between Onslow and the Lyndon River should afford some valuable information as to the mutual relations of the Permo-Carboniferous and the Nullagine Beds; hence it is from this district that the most important clue to the age of the Nullagine Series may be ultimately hoped for.

### Mosquito Creek Beds

The Mosquito Creek Beds, which underlie the strata of the Nullagine Series, comprise one of the oldest of the sedimentary formations as developed in Pilbara. The formation is abundantly represented, and occupies the surface of a very large area of country. The series, which consists of grits, shales, and fine conglomerates, takes its name from the district of Mosquito Creek, 24 miles due east of Nullagine, where these beds were first noticed.<sup>2</sup>

In that report attention was directed to the difficulty of separating the schistose rocks, which make up a large portion of the district, from these sedimentary rocks, and further observations have only served to emphasise that difficulty. As will be noted in the description of the geology of the Warrawoona field, which is made up of a mass of sedimentary strata and associated igneous rocks, converted into crystalline schists by metamorphic agencies operating on a regional scale, there seems good reason to believe that in the Mosquito Creek district the same conditions prevail.

The old 40-mile road from Mosquito Creek to Sandy and Middle

<sup>1</sup> A. Gibb Maitland. Preliminary Report on the Geological Features and Mineral Resources of the Pilbara Goldfield. Bull. No. 15. Perth: By Authority, 1904, p. 10.

<sup>2</sup> Ibid., p. 78.

Creeks follows an open longitudinal valley occupying the summit of a very broad anticlinal fold, which forms a very important structural feature in the district. It is upon the northern and southern flanks of this arch that all the auriferous quartz reefs of the Nullagine-Mosquito and Middle Creek zones occur.

A traverse from Nullagine township, south-eastward for about 6 miles to the cairn G. 16, on the summit of South Dromedary,<sup>1</sup> discloses a succession of highly inclined grits, sandstones, and shales with quartz veins. The whole series which forms the low ground underlies to the westward.

The two hills, the North and South Dromedary, which form the most conspicuous features in the landscape, rising as they do to a considerable elevation above the general level of the surrounding country, expose what appears to be the base of the Mosquito Creek Series.

The South Dromedary forms a ridge which has a general trend of north 50 degrees east, and a length of about half a mile. It is made up of vertical beds of conglomerate of considerable thickness. The conglomerate is very much cleaved, and the cleavage planes are seen to cut clean through the centre of many of the quartz and other pebbles. It may be noticed that the conglomerate contains numerous pebbles of laminated quartzite (chert), belts of which form such a conspicuous feature in other portions of the district, and are described in the previous report (Bulletin 15).

About 2 miles and a half to the south-east of Quartz Claim 32<sup>1</sup> is a cairn, forming the summit of a tortuous ridge of laminated quartzite (chert). This quartzite underlies at an angle of about 40 degrees to the west, and with an average strike of north 70 degrees east. A few feet to the west of this is a remarkably conspicuous vein of quartz of considerable horizontal extent. From the position of this laminated quartzite, it would appear as though the beds in which it is enclosed belong to an older formation than that which comprises the strata of the North and South Dromedaries.

Between this hill and the South Dromedary (G. 16), sandy and micaceous beds (? sandstones or grits) of the Mosquito Creek type prevail. These strata are traversed by numerous quartz veins, lying parallel to the planes of bedding (? cleavage).

Farther to the eastward, a normal granite makes its appearance. This granite, which is clearly intrusive into the strata just described, is traversed by pegmatite veins which have, when viewed on the whole, a general strike of north 80 degrees east. In addition to the pegmatite veins, the granite is also seamed with an approximately parallel series of quartz reefs, which may merely represent another phase of the pegmatitic intrusions.

No estimate in the present condition of our knowledge of even the approximate thickness of the Mosquito Creek Series can be made, though the apparent enormous thickness of the formation

<sup>1</sup> Vide Mines Department Lithograph, L 76.

may, in all probability, be due to the repetition of the beds by folding.

No trace of fossils having been met with anywhere in the series, so far as it has been examined, any definite data as to the age of Mosquito Creek Beds is unavailable.

Observations, fully set out on an earlier page, demonstrate that they lie unconformably beneath the Nullagine Beds, and as in certain portions of the district the Mosquito Creek Series have been subjected to more or less intense dynamic metamorphism, a considerable period must have elapsed between the deposition of the two series.

The Mosquito Creek Beds are of economic importance, by reason of the fact that they form the matrices of the numerous auriferous quartz reefs which outcrop along a belt of about 24 miles in length, and have been more or less perfunctorily worked. A full description of the reefs occurring in the Mosquito, Sandy, and Middle Creek districts has already been given in Bulletin No. 15, pp. 78-101, and need not be repeated. In this report, particulars will only be given (under the heading of Economic Geology) of those reefs, &c., embraced within the area covered by the geological map of Nullagine (Plate VIII.), and to which no previous reference has been made.

As may be seen by a reference to the table below, the gold contents of the reefs are high, having an average of nearly 3 ozs. for every ton of stone mined and milled, though the actual quantity of ore raised has, up to the present time, been very small.

*Table showing the Yield of the Auriferous Quartz Reefs of the Mosquito Creek Series.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . . . .	339·50	1,126·20	3·31
1897 . . . . .	151·00	450·95	2·98
1898 . . . . .	605·50	1,174·55	1·94
1899 . . . . .	12·70	79·60	6·27
1900 . . . . .	101·00	478·90	4·74
1901 . . . . .	28·25	187·10	6·62
1902 . . . . .	<i>Nil</i>	<i>Nil</i>	...
1903 . . . . .	<i>Nil</i>	<i>Nil</i>	...
1904 . . . . .	<i>Nil</i>	<i>Nil</i>	...
Total . . . . .	1,237·95	3,497·30	2·82

### Greenstone Dykes

Apart from the igneous rocks which form an integral portion of the Nullagine Series, the greenstone dykes make a conspicuous feature of the country in the more immediate vicinity of Nullagine.

Lying to the west of the township of Nullagine, and distant



about 2 miles, is a very prominent greenstone [5799] dyke, which attains its greatest development along the eastern bank of Kadjebut Creek. The summit of this dyke is formed of a very rocky ridge, made up of large rounded and subangular blocks of greenstone, producing in places a surface of indescribable roughness. This dyke has a general north-east and south-west strike, and extends some miles in a northerly direction far beyond the limits embraced by the Geological map. It has a width of about 1500 feet, and wherever seen in section the dyke has a decided tendency towards verticality. So far as could be seen, there appeared to be very little, if any, appreciable alteration of the enclosing rocks on either wall of the dyke. In two places along its course the dyke sends out tongues into the surrounding rocks. It is quite possible that there may be some underground connection between the main dyke and those two smaller ones which occupy a portion of the surface to the east of the Great Eastern line of reef. These two dykes, the position of which is shown on the geological map, have a horizontal extent of about 15 and 50 chains respectively.

This large, or what may be called main, dyke is nowhere seen to pierce any other strata than those of the Mosquito Creek Series.

At a point about 20 to 30 chains to the west of this larger dyke is another approximately parallel one, first making its appearance between the Victory and the Day Dawn groups of leases, and traversing the country to the northward in the vicinity of M.A. 4L until it disappears beneath the alluvium of the Nullagine River. Although it rises to a considerable height above the general level of the surrounding plain and forms a prominent surface feature, it nowhere exceeds a width of two chains. This dyke also does not pierce any other strata than those belonging to the Mosquito Creek Series.

On the north side of the Nullagine River, and in the vicinity of the One-mile Creek, is another greenstone [5794] dyke, trending generally north-west and south-east. It has been followed across country for a mile and a half, and extends far beyond the limits of the map. This dyke, which traverses both the Mosquito Creek and the Nullagine Series, does not make any very pronounced feature in the landscape, though it can be readily followed. Its width nowhere exceeds two chains in width, and when seen in section is vertical, or nearly so.

There seems very good reason for believing that this dyke may be the prolongation of that disappearing beneath the alluvium of the Nullagine River, in the vicinity of M.A. 4L. The course of the dyke north of the One-mile Creek is approximately parallel to that fault which lies to the north of Beaton's Creek, and it is quite conceivable that the One-mile Creek dyke may occur along a line of fracture also, although no obvious dislocation of the strata is apparent. Whatever may be the exact age of these dykes, it is quite clear that the one last described is newer than the series of strata it penetrates.

The rock [5799] of which this dyke is formed is of medium grained, crystalline structure. The only minerals which are readily recognisable with the aid of a lens are felspar, pyroxene, and occasionally an iron ore.

Under the microscope, relatively large proportions of crystals of augite, some of which are changed into a pale green dichroic mineral, stand out very prominently. All the felspars, which seem to be plagioclase, and make up the greater part by volume of the rock, present in all cases that turbid, mealy aspect due to alteration. The iron ore seems to be either magnetite or ilmenite, though pyrites is present in some portions.

The rock [5794] forming the largest and most conspicuous dyke in the field is a very fresh, fairly cross-grained rock, consisting of pyroxene, with a metalloid lustre, together with a white, and in some cases, almost colourless felspar, plagioclase. The felspar forms by far the larger proportion of the rock, and, when examined under the microscope, is found to be very much altered. A little quartz can be detected in some portions of the slide. The specific gravity of the rock is 2.82.

An analysis of a fresh, unweathered specimen [5794] made in the Survey Laboratory, showed its chemical composition to be—

Silica, $\text{SiO}_2$	. . . . .	54.92
Alumina, $\text{Al}_2\text{O}_3$	. . . . .	14.27
Ferric Oxide, $\text{Fe}_2\text{O}_3$	. . . . .	1.28
Ferrous Oxide, $\text{FeO}$	. . . . .	5.25
Magnesia, $\text{MgO}$	. . . . .	10.32
Lime, $\text{CaO}$	. . . . .	6.42
Soda, $\text{Na}_2\text{O}$	. . . . .	2.50
Potash, $\text{K}_2\text{O}$	. . . . .	.64
Combined Water, $\text{H}_2\text{O}$	. . . . .	2.96
Hygroscopic Water, $\text{H}_2\text{O}$	. . . . .	.12
Carbonic Anhydride, $\text{CO}_2$	. . . . .	.38
Titanic Oxide, $\text{TiO}_2$	. . . . .	.90
Iron, Fe	{ FeS <sub>2</sub> . . . . . }	{ .10
Sulphur, S		
Manganese Protoxide, $\text{MnO}$	. . . . .	trace.
		<hr/> 100.18

This apparently differs but little from that last described [5799], except in the coarseness of grain.

So far as any observations have at present been carried in the district, these dykes appear to have no apparent connection with any visible deep-seated rock of similar composition.

## ECONOMIC GEOLOGY

The Nullagine District comprises three distinct types of auriferous deposits, viz.: Alluvial and other Superficial Deposits; Quartz Reefs; and Auriferous Conglomerates. The respective yields of each is shown in the table below.

*Synoptical Table showing the Total Gold Production of the Mining Centre of Nullagine up to the end of 1904.*

Nature of Deposit.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Alluvium and Superficial . . . . .	..	3,670·02	...
Quartz Reefs . . . . .	1,237·95	3,497·30	2·82
Auriferous Conglomerates . . . . .	5,167·00	3,217·29	·62
Total . . . . .	6,404·95	16,714·59	1·04

From this table it will be noted that, in so far as the number of ounces is concerned, the alluvial and superficial deposits have proved to be the most important, whilst the yield from the quartz reefs has exceeded that from the auriferous conglomerates by 108·84 ounces, although the average grade of the quartz proves to be more than four times greater.

Considering the number of years this mining centre has been in existence, it must be candidly admitted that the gold yield is disappointing.

In addition to the above totals, 1638·50 ozs. of gold have been obtained from the cyaniding of nearly 3000 tons of tailings. It is, however, not possible to separate the yield of the tailings from each centre, but as they were all cyanided at Lambert's Treatment Works, M.A. 4L, it is probable that most of the ore was obtained from the more immediate vicinity of Nullagine itself.

*Table showing the Yield of the Tailings Cyanided at Lambert's Treatment Works, M.A. 4L.*

Year.	Tons Treated.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1902 . . . . .	1,960·00	1,259·05	·64
1903 . . . . .	840·00	379·45	·45
Total . . . . .	2,800·00	1,638·50	·58

This return thus brings the total gold yield of Nullagine up to 12,023·11 ozs., as recorded at the close of 1904.

### **Alluvium and Superficial Deposits**

The alluvium and the other superficial deposits call for no special notice, beyond the fact that there seems good reason to believe that no small portion of the "alluvial" gold was obtained

<sup>1</sup> This total does not include that of the alluvial gold.



from the numerous creeks draining that portion of the escarpment of the Nullagine Series lying between Beaton's and the One-mile Creeks. Over this area, which is that occupied by the ferruginous basal conglomerates, skilful dryblowers are still able to obtain a certain quantity of gold, derived, in all probability, from the residual concentration of the gold set free from the conglomerate. Owing to the circumstance that a considerable proportion of the gold so obtained is probably never officially reported, the actual yield from this source cannot be set out in figures.

### Quartz Reefs

Quartz reefs occur in great abundance in the country lying to the westward of the Nullagine River. These reefs outcrop over a belt about 4 miles in length, which emerges from beneath the beds of the Nullagine Series near Suburban Water Right 51, and extends in a general north-easterly direction across the whole area of the geological map. So far as any observations have been made, it seems that the productive area of the Mosquito Creek Beds, as developed in the more immediate vicinity of Nullagine, consists of a broad belt about a mile in width, with a general strike of north-east and south-west, which latter coincides with the general trend of the series.

The position of most of the quartz reefs has been accurately laid down upon the geological sketch map of Nullagine (Plate VIII.). They exhibit, when viewed on the whole, a general parallelism, which is coincident with the plane of bedding of the enclosing rocks. The reefs invariably occur along the bedding planes, or, at any rate, cut them at a very low angle. Few of them attain any very great horizontal extent, nor, so far as could be judged by a careful inspection of the surface, did they reach, as a whole, any great thickness.

The quartz of which the reefs of Nullagine are composed is generally of a whitish colour, contains little, if any, pyrites, and of such a character as renders it readily amenable to battery amalgamation and cyanidation.

Several of the reefs have been opened up and worked to relatively shallow depths.

### THE MINES.

No work of any description was being carried on at the date of my visit to the district, and none of the mines were accessible.

I have extracted a good deal of information from the manuscript reports of the different Inspectors of Mines, and the following notes may serve the purpose of giving some idea of the state of development of the mines and other cognate points at the time these officers visited the district. These notes, however, make no pretensions to being more than a mere general account. It is much to be regretted that no better official record has been kept of

the statement of development of the district, a condition of affairs which virtually obtains over the whole of such portions of the Pilbara Field as have yet been visited.

For convenience of description the various properties are dealt with in geographical order, commencing at the north-easternmost end of the field. The location of each of the properties described will be found on the geological sketch map of Nullagine. (Plate VIII.)

FISHER'S REWARD, G.M.L. 65L.—This, the most northerly of the leases in the country to the east of the Nullagine River, is traversed by two small parallel quartz reefs of no very great horizontal extent. A very little desultory work has been done upon the property, which was held for a period of about 4 months during a portion of the years 1896 and 1897. A few tons of quartz were raised and crushed in 1897; the official figures show that 20 tons of ore crushed yielded 56·6 (51·50 fine) ozs. of gold, or at the average rate of 2·83 ozs. per ton.

TRY AGAIN, 66L.—This lease adjoins that last described, on the south, and was at one period of its history known as the Turkey Mary. There are two distinct vertical reefs on the property, the easternmost having the greatest horizontal extent. The lease appears to have been held for a period of about 5 months only, during a portion of the years 1896 and 1897. Two small shafts have been sunk, but although the reef proved to be small it is stated to have been rich. There are no crushings recorded from the property.

PROMISE, G.M.L. 331 (25L).—This 6-acre lease lies some little distance to the west of the Try Again and about 35 chains to the east of the Nullagine River.

The property appears to have been held for about 18 months, having been surrendered in July 1897.

There are two short reefs outcropping near the north-western boundary of the property, and three others, the position of which is shown on the plan, adjoining. A vertical shaft, 20 feet in depth, was put down, but the Inspector of Mines' report states that there was no reef exposed in it. A second shaft, 25 feet vertical, was continued on the underlay for 25 feet farther, in a south-easterly direction, on a small quartz vein; this, in the eastern shaft, the Inspector of Mines' report states, attained a thickness of 2 feet. There appears to be no record of any crushings from this property in the official statistics, unless such are included with those from sundry claims. The field note-book, however, of the late Mr. S. J. Becher, at one time Inspector of Mines, contains the statement that "about 30 tons crushed over 90 ozs., and that the first 5 tons went 10 ozs. per ton." From this it would seem that some very rich ore must have been met with.

SUNRISE, G.M.L. 58L (480).—This lease is situated in the triangular piece of ground, bounded by the Nullagine River, Kadjebut Creek, and the gabbro dyke, shown on the geological map. A fairly well-marked quartz vein outcrops for some distance along the

eastern boundary of the lease; and has been opened out by means of a shallow shaft. Little or nothing, however, can be seen at the present time. The lease was abandoned in 1897; there are no crushings from the lease in the official statistics, unless any such are included under the heading of the yield from Sundry Claims.

SUNRISE No. 1, G.M.L. 57L (429).—This property, which adjoins the Sunrise on the north-east, appears to have been taken up in September 1896, and abandoned in the month of January of the following year. A small quartz reef, probably a continuation of the Sunrise, occupies a portion of the surface, near the south-eastern boundary of the property. The only work done on the property appears to have been raising the few tons of quartz which are shown in the official returns. These demonstrate that, previous to 1897, 28 tons of ore crushed yielded 14 (12·69 fine) ozs. of gold, or at the rate of ·50 oz. per ton.

THE GREAT EASTERN GROUP of leases lie about a mile to the south of the Sunrise, and are situated on the eastern bank of Kadjebut Creek, almost due west of the Nullagine township.

GREAT EASTERN, G.M.L. 59L.—The Great Eastern Reef makes a very pronounced outcrop, forming as it does the highest point of a low, though conspicuous ridge, which rises some 15 or 20 feet above the level of the surrounding country. The general strike of the reef is north-easterly, and, as measured at the surface, has an underlie of 70 degrees to the south-west; from this it would seem that the reef is much steeper at the surface than underground. The country rock of both walls of the reef is slate; the reef measures about 4 feet in thickness, and the quartz is white, with ferruginous portions, due to the oxidation of pyrites. A fair quantity of stone from the outcrop had been raised to a depth of from 15 to 20 feet from the ground level. Mr. Inspector Gladstone's report mentions a vertical shaft 40 feet in depth, which had been continued on the underlay for a distance of 80 feet. At 30 feet in the shaft, a level is referred to 35 and 40 feet in length, driven respectively north-east and south-west, whilst at 90 feet a north-easterly level had been driven for a horizontal distance of 40 feet. There is no information in Mr. Gladstone's report as to the dimensions or character of the reef in the mine, and the workings were inaccessible to me.

The following figures give the yield of the reef in so far as it may be gained from official data:—

*Table showing the Yield of the Great Eastern Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Fine Ozs.	Fine Ozs.
Previous to 1897 . . .	20·00	30·63	1·52
1898 . . . . .	150·00	160·08	1·06
Total . . . . .	170·00	190·71	1·12



ENTERPRISE, G.M.L. 76L.—This is an isolated lease about three-quarters of a mile to the north-west of the Great Eastern Group. It embraces a part of the old Union Jack Lease 40L. A fairly well-defined reef, which can be followed more or less interruptedly across the surface to the south-west for a distance of 2500 feet, traverses the lease. Several shafts have been sunk to depths of which there is no information. Water is said to have been met with in two of them at 35 feet. These shafts have been utilised as a source of water for the Battery and Cyanide Plant at one time erected on M.A. 4L, which embraces part of the lease. There have been no crushings recorded from the property, unless they are included in the yield from Sundry Claims.

In the vicinity of this lease there are several other parallel reefs of smaller size, upon which a little work has been done at one time or another, but there are no particulars available in respect to the yield of any of them.

About 800 feet to the south-west of the Enterprise Reef is another parallel vein, which can be followed more or less interruptedly across the surface for about 3000 feet, and it is quite possible that the reef, disappearing beneath the alluvial flat of the Nullagine River to the north-west of the Day Dawn Group, may represent an extension of it.

SCOTTISH CHIEF, G.M.L. 64L.—This is an old abandoned 12-acre lease, adjacent to the Day Dawn Group on the north. There are three well-defined though small reefs traversing the property, and upon two of them, the north and south reefs, shafts have been sunk; these, however, are inaccessible, hence no particulars are available. There do not appear to have been any crushings recorded from the property.

DAY DAWN, G.M.L. 278 (17L).—Upon this property there are several well-defined parallel reefs outcropping. The reefs have an average strike of north-east, with an underlie of about 40 degrees to the south-east. The main reef, viz., that upon which the bulk of the work has been carried out, averaged on the surface about 2 feet in thickness. It consisted of a white, and, in places, very ferruginous quartz, and is stated by Mr. Inspector Becher to have contained very coarse gold. Mr. Becher notes that the reef had been opened by means of an underlay shaft 45 feet in depth, which was also connected with the surface by a vertical shaft of 20 feet. A little driving had been done along the reef to the south-east. At a later date, 1898, Mr. Inspector Gladstone notes that the shaft had been carried down to a depth of 69 feet, and that driving to 252 feet had been carried out. No particulars as to the nature of the reef underground is to be found in the reports of the inspectors, which is much to be regretted, as the workings are at the present time inaccessible. Only 266 tons of stone have been crushed during the three and a half years the lease was in existence, particulars of which are shown in the table below. In addition to these figures, Mr. Becher notes that 18 tons of

débris, with which the surface of the lease was covered, yielded 18 ozs. of gold.

*Table showing the Yield of the Day Dawn Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Fine Ozs.	Fine Ozs.
Previous to 1897 . . .	174·00	543·78	3·45
1898 . . . . .	92·00	94·89	1·11
Total . . . . .	266·00	638·67	2·64

DAY DAWN No. 1 SOUTH, G.M.L. 388 (43L).—A 12-acre lease, adjoining that previously described, which was held for a little over 12 months and abandoned in December 1897. Two short reefs, one of which may represent the extension of the Day Dawn, occupy a portion of the south-western corner of the ground. Very little work appears to have been done upon the property, and there is no record of any crushings from it.

DAY DAWN NORTH, G.M.L. 418 (52L).—No work of any moment appears to have been done upon this lease.

THE VICTORY GROUP of leases, only one of which, however, is now extant, occupies an extent of country about a mile in length, over which several small quartz veins outcrop.

VICTORY, G.M.L. 134L.—This lease embraces the greater portion of what was originally the Victory East Extended, G.M.L. 56L (424 or 99L), Walter's Folly; the original Victory, G.M.L. 383 (42L), to which it is desirable the name should be still applied, is situated some little distance southwards along the line. Five shafts have been sunk upon the lease, and, judging by the condition of the dumps, a good deal of work must have been done. None of the shafts, however, were accessible to me, and there appear to have been no plans of the workings. Mr. Inspector Gladstone mentions two underlay shafts, each 135 feet deep, and connected with drives from which 172 tons of ore had been crushed for a return of 625 ozs. of gold, and a main shaft, which at the date of his visit had been carried down 70 feet.

*Table showing the Yield of the Victory (East Extended) Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . .	12·50	50·90	4·07
1897 . . . . .	42·00	195·25	4·65
1898 . . . . .	116·00	388·30	3·34
1899 . . . . .	<i>Nil</i>	<i>Nil</i>	...
1900 . . . . .	89·00	414·35	4·65
1901 . . . . .	25·50	181·00	7·09
Total . . . . .	285·00	1,229·80	4·31

According to the official records of the mine, given in the preceding table, the gold yield seems to have been high.

VICTORY NO. 1 EAST, G.M.L. 53L (419).—Known later as the New Victory Extended, G.M.L. 70. The reef, traversing the adjoining property previously described, extends more or less interruptedly along the south-eastern boundary of the lease. It has been opened up by an inaccessible vertical shaft, of a depth of which there appears to be no record. There are no returns of any crushings from this lease.

VICTORY, G.M.L. 383 (42L).—What is known as the main Victory reef traverses the south-eastern boundary of the property, though it makes very little show on the surface. An inaccessible underlay shaft had been carried down, according to Mr. Becher's notes, to a depth of 81 feet, on a quartz reef underlying at an angle of 60 degrees, and attaining a thickness of from 3 to 4 feet. The walls of the reef, as described by Mr. Becher, are "perfect," and are made up of a soft, fine-grained, solid, white sandy shale, which is stated to harden on exposure. The quartz is very highly coloured by oxide of iron, and, according to Mr. Becher, showed gold freely at the bottom. A vertical shaft was being put down at a spot 50 feet distant from the mouth of the underlie shaft, designed to intersect the main reef at about 80 or 90 feet, but there is no official record as to whether this was accomplished. At the time Mr. Becher was at work in the Nullagine district, a small crushing of 25 tons of stone from the reef in the inclined shaft is reported to have yielded 130 ozs. of gold, or at the rate of 5·20 ozs. per ton of ore crushed. A small trial crushing of a few tons by former holders of the property yielded gold at the rate of 3 ozs. per ton. The official yield of this lease is given in the table below.

*Table showing the Yield of the Victory Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . .	75·00	337·50	4·50
1897 . . . . .	46·00	83·60	1·81
Total . . . . .	121·00	421·10	3·48

VICTORY EXTENDED, G.M.L. 51L (417).—A small 6-acre lease adjoining G.M.L. 383 on the south-east, and traversed by a reef which was thought to be the southern extension of the Victory. So far as can be judged, however, it seems probable that it is a parallel reef. An underlie shaft had been carried down on the reef to a depth of 30 feet, when it cut out. The shaft, however, was carried down another 20 feet, at which point a crosscut had been put in 20 feet to the north, with the object of testing the country, and another crosscut to the south had been commenced at



the date of Mr. Becher's visit. His notes, however, give no particulars as to whether the reef had been picked up below the depth at which it cut out. In 1897, 22 tons of ore are officially recorded as yielding 63 ozs. of gold, or at the rate 2·86 ozs. per ton.

MARQUIS, G.M.L. 62L.—A disused and inaccessible shaft is situated at a point 13 feet from the north-east angle of the lease, and is traversed by a small reef parallel to that in the adjoining property on the north. About 100 feet south from the north-east angle is a well-defined reef, shown on the geological map, underlying at a high angle to the north-west, but no work has been done upon it.

There are one or two other abandoned leases and quartz claims in the vicinity of Kadjebut Creek to the west of the South Dromedary G. 16. The position of these properties is shown on the 40-chain lithograph L 76, issued by the Department of Mines.

GOLDEN EAGLE, G.M.L. 77L (formerly Alexandra, G.M.L. 71L).—A great deal of desultory work has been carried out upon what were evidently distinct veins, but all the workings are inaccessible at the present time. According to the official records, small crushings from this lease took place annually from 1897 to 1901, but although the total quantity of gold, under 500 ozs., so obtained was small, the average per ton was over  $4\frac{1}{2}$  ozs. There would thus seem to have been some very rich shoots met with in the course of the work.

*Table showing the Yield of the Golden Eagle Reef.*

Year.				Ore Crushed.	Gold therefrom.	Rate per Ton.
				Tons.	Ozs.	Ozs.
1897	.	.	.	21·00	52·50	2·50
1898	.	.	.	57·50	290·20	5·04
1899	.	.	.	12·70	79·60	6·26
1900	.	.	.	12·00	64·55	5·38
1901	.	.	.	2·75	6·10	2·22
Total.				105·95	492·95	4·65

REWARD CLAIM, 33L.—A small abandoned lease on the eastern bank of Kadjebut Creek, and lying about three-quarters of a mile to the south-east of the Golden Eagle. An east and west vertical reef has been opened up by a shaft which is inaccessible at the present time, hence no information as to the character and behaviour of the reef underground can be obtained. There appear to be no records of any crushings from this property, unless they are included under the heading of the yield from Sundry Claims.

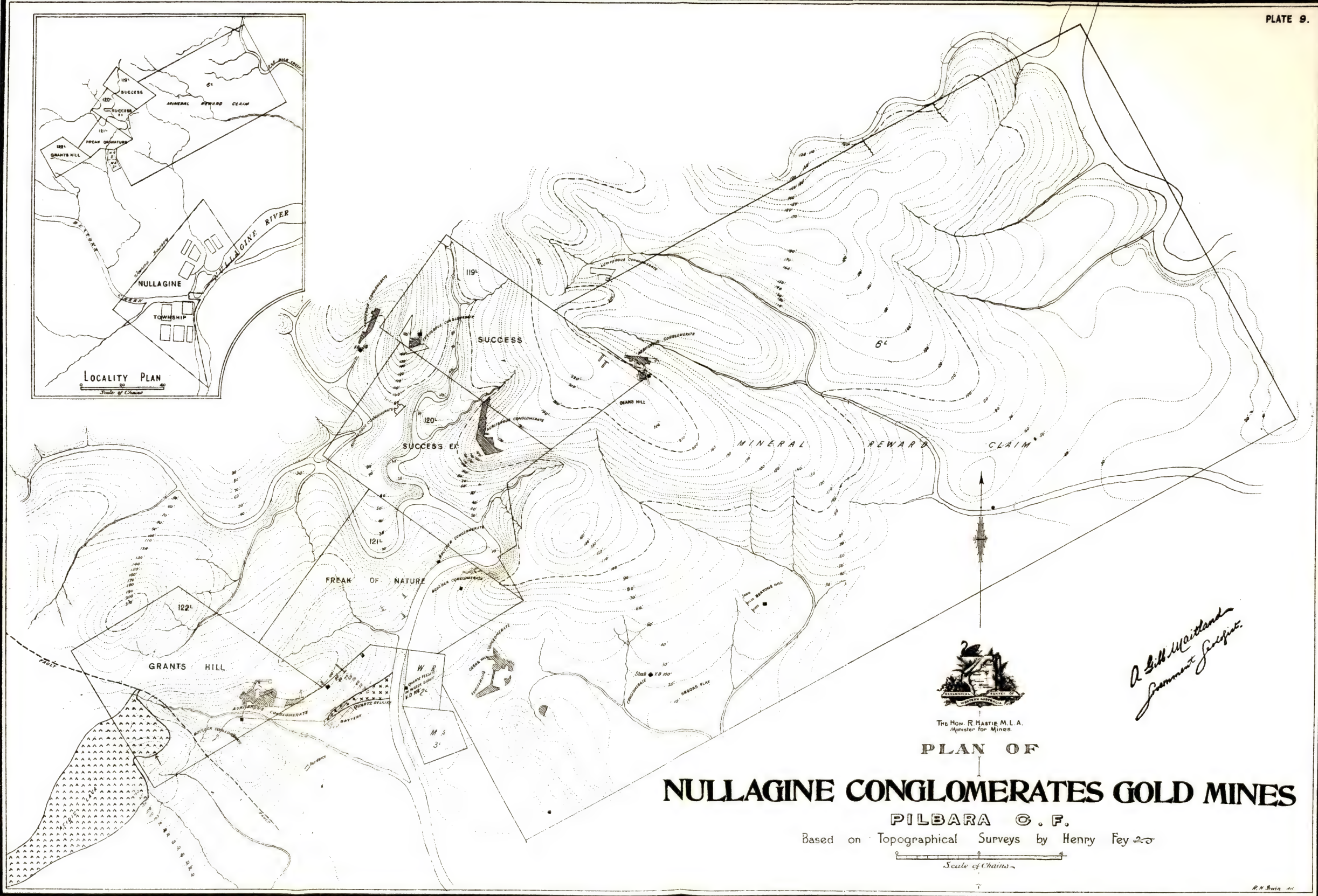
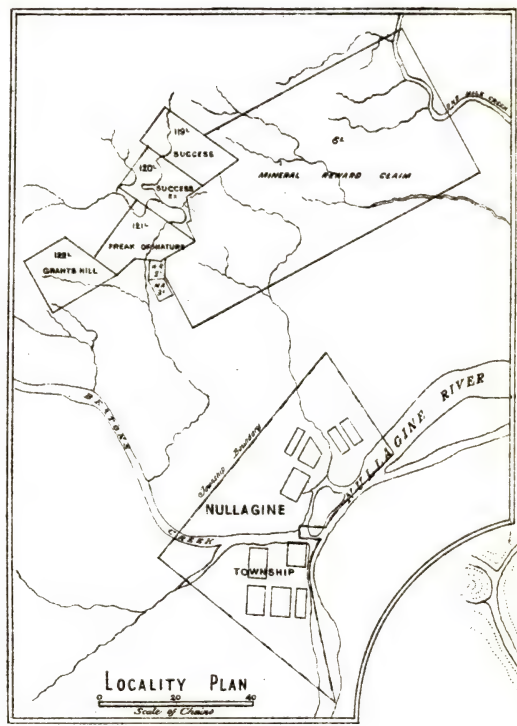
The following synoptical table gives the total gold yield of the reefs of Nullagine, in so far as such may be obtained from official statistics:—

Table showing the Yield of the Auriferous Quartz Reefs at Nullagine.

Name of Lease.	Number of Lease.		Owner.	Remarks.	Prior to 1897.		1897.		1898.		1899.		1900.		1901.		1902.		1903.		1904.		Total.	
	Marble Bar Number.	L. Number.			Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.
Day Dawn . . . . .	278	17	Doherty and Party . .	Abd., 14/8/99 . . . . .	Tons. 174'00	Ozs. 600'00	..	..	Tons. 92'00	Ozs. 102'70	..	..	..	..	..	..	..	..	..	..	..	..	Tons. 266'00	Ozs. 702'70
„ No. 1 S. . . . .	388	43	J. Isdell . . . . .	Abd., 24/12/97 . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ North . . . . .	418	52	„ . . . . .	Ftd., 24/12/97 . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Promise . . . . .	331	25	Farley & White . . . .	Surr., 19/7/97 . . . . .	1 30'00	90'00	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	30'00	90'00
Fisher's Reward . . . .	..	65	Fisher & Martin . . . .	Abd., 31/3/97 . . . . .	..	..	20'00	56'60	..	..	..	..	..	..	..	..	..	..	..	..	..	..	20'00	56'60
Try Again . . . . .	..	66	Walters Nicholls . . . .	Abd., 21/4/97 . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Victory . . . . .	383	42	Geo. Holcombe . . . . .	Surr., 3/5/96 . . . . .	75'00	337'50	46'00	83'60	..	..	..	..	..	..	..	..	..	..	..	..	..	..	121'00	421'10
„ Extended . . . . .	417	51	„ . . . . .	Surr., 3/5/98 . . . . .	..	..	22'00	63'00	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22'00	63'00
Golden Eagle . . . . .	..	77	Johns & Smythe . . . .	Late 71L, Alexandra . .	..	..	21'00	52'50	57'50	290'20	12'70	79'60	12'00	64'55	2'75	6'10	..	..	..	..	..	..	105'95	492'95
„ No. 1 E. . . . .	419	53	Royer, Ahern, &c. . . .	Ftd., 9/4/97. Later 70L, New Victory Extended	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Victory East Extd. . . .	424	56	W. Extd. Volunteer Pros. Association	Ftd., 14 7/99 . . . . .	12'50	50'90	42'00	195'25	116'00	388'30	..	..	..	..	..	..	..	..	..	..	..	..	170'50	634'45
Walter's Folly . . . . .	..	99	Alfred Royer . . . . .	Voided 6/9.01. Late 56L	..	..	..	..	..	..	..	..	89'00	414'35	25'50	181'00	..	..	..	..	..	..	114'50	595'35
Victory . . . . .	..	134	Aikman & Giles . . . . .	Late 99L . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Marquis . . . . .	..	62	Maher, Wiberg, &c. . . .	Ftd., 25/6/97 . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Sunrise No. 1 . . . . .	429	57	Turner & Travis . . . .	Abd., 18/1/97 . . . . .	28'00	14'00	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	28'00	114'00
Sunrise . . . . .	430	58	Aikman & Higgs . . . .	Abd., 29/1/97 . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gt. Eastern No. 1 . . . .	423	55	Garland & McKenna . . .	Abd., 18 9/96 . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gt. Eastern Extd. . . . .	..	61	Doherty & Jenkin . . . .	Abd., 19/1/99 . . . . .	..	..	..	..	190'00	224'40	..	..	..	..	..	..	..	..	..	..	..	..	190'00	1224'40
Great Eastern . . . . .	..	59	Isdell, McKenna, &c. . . .	..	20'00	33'80	..	..	150'00	168'95	..	..	..	..	..	..	..	..	..	..	..	..	170'00	202'75
„ No. 1 . . . . .	..	72	Isdell, Connolly, Holcombe	Abd., 1/12/97. Part in 75L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Scottish Chief . . . . .	..	64	Eatch, Townsend, &c. . .	Abd., 20/1/97 . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Enterprise . . . . .	..	76	Jenkin, Garland, &c. . .	Ftd., 13/10.99. Part of 40L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total . . . . .					339'50	1,126'20	151'00	450'95	605'50	1,174'55	12'70	79'60	101'00	478'90	28'25	187'10	..	..	..	..	..	..	1,237'95	3,497'30

<sup>1</sup> From Inspector of Mines MS. Notes.





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# PLAN OF NULLAGINE CONGLOMERATES GOLD MINES PILBARA C. F.

Based on Topographical Surveys by Henry Fey 20





*Synoptical Table showing the Yield of the Nullagine  
Reefs up to the end of 1904.*

Name of Reef.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Day Dawn . . .	266·00	702·70	2·64
Fisher's Reward . . .	20·00	56·60	2·83
Golden Eagle . . .	105·95	492·95	4·65
Great Eastern . . .	170·00	202·75	1·19
Great Eastern Extended .	190·00	224·40	1·18
Promise . . .	30·00	90·00	3·00
Sunrise No. 1 . . .	28·00	14·00	·50
Victory . . .	121·00	421·10	3·48
Victory East Extended .	285·00	1,229·80	4·31
Victory Extended . . .	22·00	63·00	2·86
Total . . .	1,237·95	3,497·30	2·82

### Auriferous Conglomerates

Mining operations have, up to the present, been confined exclusively to the outcrop of the conglomerates and to very limited and shallow depths; but work, however, has been carried sufficiently far to enable some idea of the conditions governing the gold deposition being ascertained. The conclusions to be drawn from these data may have some influence upon the practical development of the field. The gold contents of the conglomerate are small, not amounting to more than 3217·29 ozs. derived from the milling of 5167 tons of ore, or at the rate of ·62 oz. per ton.

Of the different areas in which the conglomerate has been worked, the largest quantity of gold, so far as may be judged by the official figures, appears to have been obtained from the workings now embraced by the Grant's Hill Lease 122L (*vide* the plan of the Nullagine Conglomerate Gold Mines, Plate IX.). The returns from this demonstrate that 3433 tons of ore yielded 1780·24 ozs. of gold, or at the rate of ·52 oz. per ton.

The auriferous conglomerate, which has already been shown to be of sedimentary origin, is made up of rounded and subangular fragments of the strata identical in character with that forming the underlying Mosquito Creek Series. Certain portions of the conglomerate are marked by the presence of abundant iron pyrites, and its oxidation products [5802, 5806]. It is, however, in the oxidised zone of the conglomerate that any mining has, up to the present, been carried on.

In 1897, samples of the auriferous conglomerate were examined in the Survey Laboratory, and have been thus described:—

“A specimen [190] typical of the finer grained portions of the rock in its upper decomposed portions. It consists of subangular fragments of quartz, ironstone and shale, cemented together by iron-stained kaolin, containing numerous cuboidal cavities at one

time filled by pyrites crystals, as shown by the numerous pseudomorphs of limonite contained by them. . . . It assays 1 oz. 6 dwts. of gold. . . . A similar but less ferruginous variety [191], showed no cavities vacated by pyrites, and is much coarser in grain, some of the fragments of quartz being 3 inches in length; it assays 2 ozs. 1 dwt. of gold per ton.”<sup>1</sup>

Another variety [192] made up of large pieces of felstone, with smaller fragments of quartz embedded in a kaolinic matrix, assayed 10 dwts. of fine gold and 5 ozs. 4 dwts. of coarse gold per ton.

A noteworthy feature in the conglomerate is the occurrence of pyrites and its oxidised representatives. In the unoxidised portions [3718, 5801, 5802] the pyrites occurs both as crystals, grains, and rounded or pebble-like forms. A photograph of a small but characteristic form [5802] is shown in Fig. 32. Some of the pyrites nodules measure an eighth of an inch in diameter, though from the size of some of the hematite pebbles there must be some which reach as much as three-quarters of an inch in diameter. A photograph of one of these hematite pebbles [5801] forms Fig. 33.

Considerable interest attaches to the occurrence of these rounded pebbles and pellets of pyrites and hematite in that they have been held to indicate a detrital character as well as ascribing a similar origin to the gold, which seems invariably to be associated with the occurrence of the ores of iron in the conglomerate.

A radiate fibrous structure can be detected in some of the oxidised conglomerates [5801] when the hematite pebbles exhibit fractured surfaces.

In some portions of the conglomerate [190] these hematite fragments make up fully one-half of the rock. The gold [1509, 3167] in the conglomerate almost invariably occurs in or lining the sides of these cavities which have been left by the removal of the iron ore. All its characters point to the gold having been left where it is now found by the oxidation of the pyrites.

The evidence, so far as it goes, respecting the origin of the gold in the Nullagine conglomerate seems to indicate that it is a secondary, and not an original constituent, and further that the primary source of the gold is the quartz reefs which occur in the underlying formation.

From the known occurrence of auriferous quartz reefs, which furnished no small portion of the pebbles of certain portions of the deposit, it is of course quite conceivable that a certain amount of detrital gold forms part of the conglomerate, but there are obviously no means of ascertaining what is the proportion of primary to secondary gold.

There seems, however, good reasons for believing that by far the bulk of the gold, together with the pyrites, was introduced by solutions percolating down the most porous portions of the con-

<sup>1</sup> Annual Progress Report of the Geological Survey for the Year 1897. Perth: By Authority: 1898, p. 48.





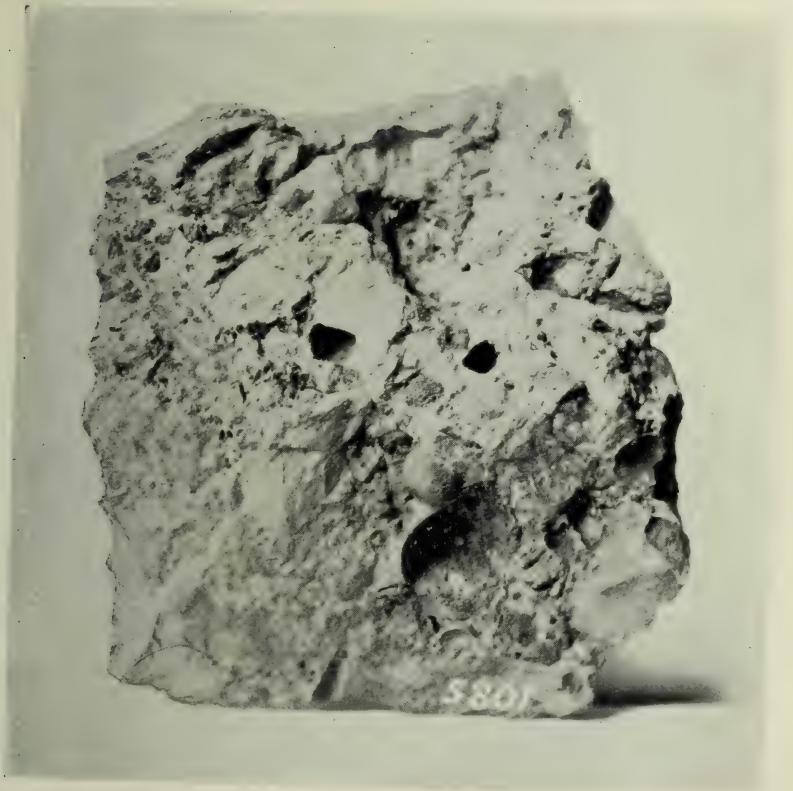
**Fig. 32.**



*Photo.: E. S. Simpson.*

**Rounded Pyrites Pebble in Conglomerate, Nullagine Series.**

Fig. 33.



*Photo.: E. S. Simpson.*

**Rounded Hematite Pebbles in Conglomerate, Nullagine Series.**





glomerate, this condition being facilitated by the downward inclination of the bed-rock, and, possibly, accentuated in part by the folding which the strata have undergone.

The intrusion of felsite into the lower portion of the conglomerate (Plate IX.), and the volcanic phenomena of which it formed a part, may possibly have resulted in the formation and circulation of the mineralising solutions, and also the deposition of the gold.

There is no evidence that the diabase dyke and the fault (Plate VIII.) have had any beneficial effect upon the gold contents of the conglomerate, but the fact remains that it is only in that portion of the formation lying between these two lines of fracture that any gold has hitherto been found. It is also noteworthy that the base of the Nullagine Series has only proved auriferous in those places where it lies upon that portion of the underlying formation which carries auriferous deposits. It may be noted, also, that over that portion of the formation from which the conglomerate crushings have been obtained, numerous dryblowers have been at work for a number of years, and have obtained a considerable quantity of gold, of which the published figures afford no clue, for much of it in the early days was probably never officially reported.

Probably one-half of the alluvial gold from Nullagine, shown in the figures on page 128, may be legitimately claimed as having been derived from the escarpment of the conglomerate.

The high assays [190, 191, 192] alluded to are the exception, and merely indicate the occurrence of unusually rich shoots in portions of the conglomerate.

No attempt was made to sample any portion of the conglomerate workings, with the view of arriving at the value of the deposits, but six samples (which seemed to be characteristic of the type of deposit), collected during the course of the fieldwork, were assayed in the Departmental Laboratory, with the following results :—

- [5800].—Grant's Hill Lease 122L. Oxidised Conglomerate in which the iron had been entirely leached out. Gold, 6 dwts. 23 grs. per ton.
- [5801].—Grant's Hill Lease 122L. Oxidised Conglomerate, with abundant hematite kernels. Gold, 2 dwts. 11 grs. per ton.
- [5806].—Dean's Hill, Mineral Reward Claim 6L. Oxidised Conglomerate with hematite kernels (some portions of this conglomerate show free gold). Gold, 4 dwts. 2 grs. per ton.
- [5802].—Freak of Nature, G.M.L. 121L. Pyritous sulphide conglomerate. Gold *nil*.
- [5803].—North-west of the Success, G.M.L. 119. Very slightly pyritous conglomerate. Gold *nil*.
- [5804].—North-west of the Success, G.M.L. 119. Non-pyritous conglomerate. Gold *nil*.

To arrive at the value of the deposits, as can be readily understood, is an exceptionally difficult matter, but the figures of the

output afford some idea of the yield of those isolated portions of the conglomerate which were deemed worth working.

The records of production of the conglomerates, given in the table on an earlier page (p. 128) seem to indicate a general decrease in the yield, the latest crushing of 777 tons returning gold at the rate of .12 ozs. per ton.

Fluctuations in the gold yield per ton are, of course, only to be expected, but it cannot be said that the average of all the crushings recorded is any index to the value of the whole of the conglomerate series, if worked upon a large scale. It would probably prove to be a very low grade, and possibly so low as to render remunerative working, unless under the most favourable economic conditions, impossible.

The known occurrence of such an extensive formation as the Nullagine Series has proved, by mapping, to be, and the fact that it has been shown to contain considerable quantities of gold in localities where the requisite and qualifying conditions for deposition obtain, would seem to encourage efforts in the direction of carefully prospecting other parts of the basal members of the series in the district.

Such prospecting should be a relatively easy task, seeing that it has already been shown that the auriferous portions of the conglomerate have invariably proved to be those which are the most ferruginous, hence the search for ironstained conglomerates near the base would seem to be the lines upon which such efforts should tend.

#### THE MINES.

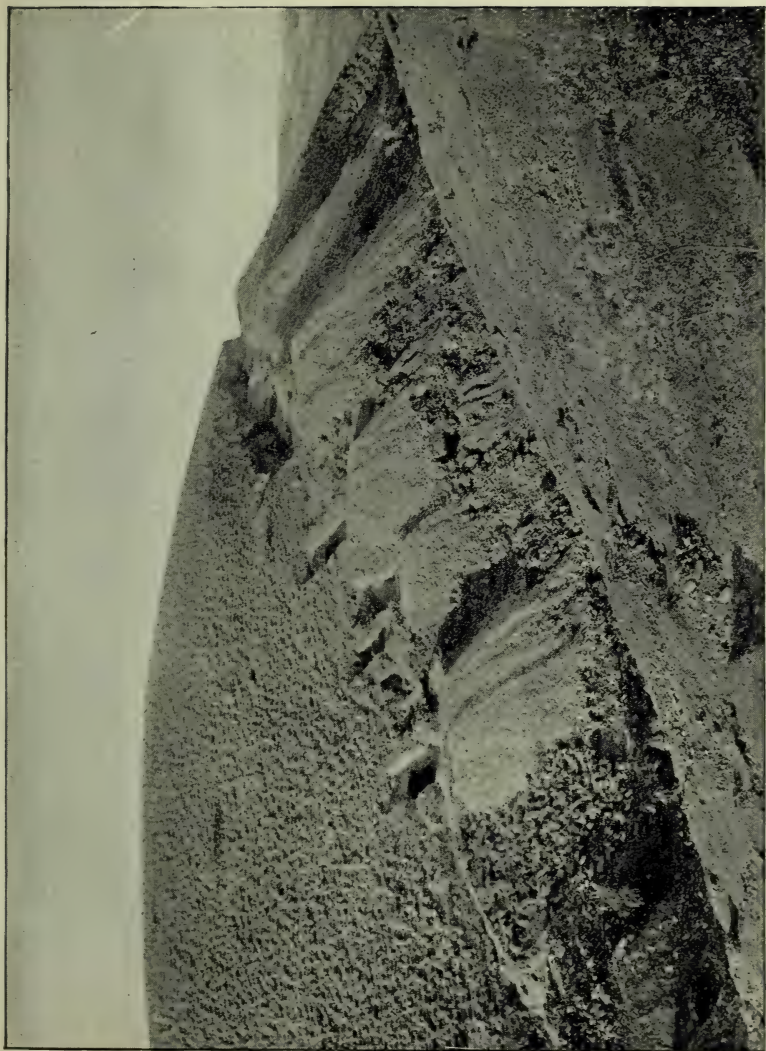
GRANT'S HILL, G.M.L. 122L.—A considerable amount of *bond fide* work has been done upon the western angle of the lease, as may be seen by an inspection of the plan of the Nullagine Conglomerates Gold Mines (Plate IX.).

Fairly extensive workings on the south side of the tramline which connects with the battery have been carried on in a bed of coarse conglomerate, the exact thickness of which does not appear to have been determined. The conglomerate (or boulder bed) contains large boulders of flat-sided quartz, siliceous conglomerate, and other rocks occurring in the vicinity. This portion of the workings lies in the oxidised zone of the conglomerate which contains cellular portions from which iron pyrites has weathered out [5800]. This sample assayed in the Departmental Laboratory 6 dwts. 23 grs. of gold per ton.

The larger portions of the workings, however, occur on the southern slopes of Grant's Hill, which lies on the north side of the creek which drains the gully in a westerly direction. (Fig. 34.)

A good deal of ore must have been taken out at one time or the other, for the workings extend for some considerable distance round the slope of the hills. The larger portion of the work has been carried out on a bed of conglomerate, underlying generally

Fig. 34.



*Photo. : S. J. Becher.*

Workings on the Grant's Hill Conglomerate, Nullagine.





west-north-west, rising gradually up and along the hillside at an angle of about 40 degrees, and as the plan (Plate IX.) and statistics show, a good deal of ore must have been taken out.

A fault with a very small displacement occurs in one portion of the workings, and it appears to be parallel to the main fault shown on the geological and mining maps (Plates VIII. and IX.).

A thickness of only from 3 to 4 feet of the conglomerate has been worked. So far as can be gathered from the official statistics, the returns from what is now Grant's Hill are set forth in the table:—

*Table showing the Yield of the Grant's Hill Conglomerate.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Oz. £.
Previous to 1897 . . . .	109·00	147·00	1·35
1897 . . . . .	<i>Nil</i>	<i>Nil</i>	...
1898 . . . . .	275·00	382·35	1·39
1899 . . . . .	462·00	343·25	·74
1900 . . . . .	152·00	70·50	·46
1901 . . . . .	1,358·00	614·53	·45
1902 . . . . .	300·00	128·51	·42
1903 . . . . .	777·00	94·10	·12
1904 . . . . .	<i>Nil</i>	<i>Nil</i>	...
Total . . . .	3,433·00	17,80·24	·52

To what may be called the Grant's Hill conglomerate should be added the small crushing of 85·40 tons, which yielded in 1899 40·70 ozs. of gold, or at the rate of ·47 oz. per ton, from what was originally known as the Trinity No. 1 South, G.M.L. 422, and subsequently Grant's Hill South, G.M.L. 68L.

This old 12-acre lease adjoined the present Grant's Hill lease on its southern boundary, and apparently included the ground now occupied by the "Residence" shown on the plan of the Nullagine Conglomerates Gold Mines (Plate IX.). The conglomerate from which the crushing was taken occupied the crown and the north-western slope of the hill lying to the east of the main fault. This hill formed a very rich field for dryblowers in the early days of Nullagine.

This additional crushing brings the total return from the Grant's Hill conglomerates up to 1820·94 ozs., obtained from the milling of 3518·40 tons of ore, or at the rate of ·51 oz. per ton.

FREAK OF NATURE, G.M.L. 121L.—What is now the Freak of Nature Lease includes the ground originally embraced by the Freak of Nature, G.M.L. 208, the Freak of Nature Extended, G.M.L. 21, and the Exchange, G.M.L. 18.

The most easterly working near the eastern angle of Grant's Hill was originally known as Neale's No. 3 Underlay. Work in this shaft had been confined to a bed of conglomerate, 3 feet in

thickness, underlying to the north-west at angles varying from 18 to 20 degrees. The late Mr. Inspector Becher sampled this conglomerate, and reported the prospects to be "fair."

It would seem that this conglomerate is on the same horizon as that exploited in the adjoining Grant's Hill Lease.

The next working, on a slightly lower horizon, was known as Hewett's Shaft, and a little work was done upon a conglomerate from 2 feet 6 inches to 3 feet 6 inches in thickness; from this locality Mr. Becher also obtained "fair" prospects. This conglomerate appeared to be much more kaolinic than that in Neale's shaft.

Another shaft, shown upon the plan, had been put down upon a conglomerate, on a lower horizon, but no particulars respecting it are available.

There appears to be no record in the statistics of any crushings having been made on the old Exchange Lease; should any have been recorded they may be included in the yield from Sundry Claims, &c. It does not, however, appear from the conditions of the workings that any very large body of ore can have been taken out. From that portion of the present Freak of Nature Lease, which embraces the old Freak of Nature, G.M.L. 208 (1L), practically no work seems to have been done.

At a point on the northern bank of the main creek, near the north-eastern boundary of the lease, is a cliff of unoxidised pyritous conglomerate, which is distinctly banded.

A typical sample [5802] of this pyritous conglomerate, when assayed in the Departmental Laboratory, yielded, however, no trace of gold.

On the south-eastern portion of the lease, lying to the south of the pyritous conglomerate previously described, and in the ground originally embraced by the old 5-acre lease, Freak of Nature Extended, a big tunnel (Plate IX.) has been put in, upon a boulder conglomerate. Judging by the present condition of the workings there seems to have been a good deal of work done, and a fairly large quantity of stone taken out. Mr. Becher's note-book indicates that the result of his sampling was that the prospects were "poor."

There are no official records of the yield of this portion of the property.

SUCCESS EXTENDED, G.M.L. 120L.—This 24-acre lease embraces part of the old Rejected, G.M.L. 414, Success, G.M.L. 352, and the Freak of Nature, G.M.L. 208. It is, however, only in the old Success and the Rejected that any mining work has been done.

The small patch lying between the 80 and 90 feet contours, in the northern portion of the ground, form the Rejected workings; in reality merely an open work on the outcrop of a bed of conglomerate.

Operations, however, have been principally confined to the old Success ground, and the extent of the open work is indicated on the mining plan which forms Plate IX. So far as may be gathered at



the present time the auriferous conglomerate, which did not differ from any of the other auriferous beds, varied in thickness from 18 inches to 2 feet. The table below gives the total gold yield, so far as can be gathered from the official figures; the 547 tons of ore crushed were in all probability obtained from this portion of the lease.

*Table showing the Yield of the Success Extended Conglomerate.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . . . .	32·00	42·00	1·31
1897 . . . . .	<i>Nil</i>	<i>Nil</i>	...
1898 . . . . .	305·00	349·25	1·14
1899 . . . . .	110·00 <sup>1</sup>	115·00	1·04
1900 . . . . .	<i>Nil</i>	<i>Nil</i>	...
1901 . . . . .	100·00	33·00	·33
Total . . . . .	547·00	539·25	·98

SUCCESS, G.M.L. 119L.—This 24-acre lease, as it now stands, includes within its boundaries the old Barney's Hill United, G.M.L. 276 (upon which most of the work has been done), and a portion of the Success, G.M.L. 352.

The conglomerate worked on Barney's Hill lies at about the highest altitude of any of the beds at present opened up, being about 100 feet vertically above that in Grant's Hill. The workings lie pretty nearly upon the summit of the hill and along its southern slopes; the bed has been stripped along its outcrop for some distance round the southern and western slopes, and a vertical shaft 25 feet in depth has been sunk, intersecting a drive put in along the conglomerate for some distance from the outcrop.

Over 300 tons of ore have been raised from the Barney's Hill workings. The figures given in the table as being the yield of the present Success Lease were derived from ore obtained exclusively from the Barney's Hill workings.

*Table showing the Yield of the Success Conglomerate.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . . . .	80·00	100·15	1·25
1897 . . . . .	246·00	228·00	·92
1898 . . . . .	12·00	23·10	1·92
Total . . . . .	338·00	351·25	1·03

<sup>1</sup> The 96 tons yielding 34·40 ozs. from the Cook's Hill workings, credited in the official return to the Success Lease, are not included in this total, but are included in the yield of M.R.C. 6L.

BARNEY'S HILL No. 1 NORTH, G.M.L. 24L (330).—This 6-acre lease, which was abandoned in 1897, embraces the workings (Plate IX.) lying near the western angle of G.M.L. 119L. Operations have been confined to a bed of very coarse ferruginous conglomerate, containing very large ellipsoidal boulders. At a slightly lower level on the north side of a gully flowing southwards from the south-west angle of G.M.L. 119L is a vertical shaft, 50 feet in depth, in which 5 or 6 feet of water were standing. This shaft, which was inaccessible, had been carried down through conglomerate of the usual type, and, judging by the material at grass, it contained a little pyrites. A characteristic portion of the pyritous conglomerate [5803] yielded no gold on assay in the official laboratory.

The only returns from the Barney's Hill United Lease appear to have been prior to 1897, when a small crushing of 20 tons yielded 25 ozs. of gold, or at the rate of 1.25 ozs. per ton. These figures indicate that portions of the conglomerate, in this part of the field, are auriferous.

MINERAL REWARD CLAIM, 6L.—This Reward Claim, which comprises an area of 320 acres, includes within its boundaries the old leases: Golden Crown, G.M.L. 365 (31L); Beaton's Hill, G.M.L. 373 (37L); Cook's Hill, G.M.L. 412 (47L); Rejected No. 2, G.M.L. 416 (50L); together with parts of Golden Promise No. 1, G.M.L. 67L, and Central No. 1, G.M.L. 69L.

Near the easternmost angle of G.M.L. 119L, and to the north of Dean's Hill, are a series of extensive workings upon what was originally the Golden Crown, G.M.L. 365, at an altitude of over 200 feet above the low ground at the base of the formation. All the ground on the flanks of the hill below these workings has been dryblown, and, during Mr. Inspector Becher's term of office, the average winnings from this source are stated to have amounted to about 18 dwts. per man per day. The conglomerate, which lies in the locality practically horizontally, is of the usual ferruginous type, containing large pellets of hematite. A typical sample of this highly ferruginous variety from the open-work [5806] assayed in the Departmental Laboratory gold at the rate of 4 dwts. 2 grs. per ton. The total returns from the Golden Crown workings, as shown in the table below, gives the yield as 189.90 ozs. obtained from the milling of 223.60 tons of ore, or at the rate of .84 oz. per ton.

What is known as the Cook's Hill workings are situated due east of W.R. 2L. Cook's Hill is said to have derived its name from Mr. Nat. Cook, who is credited with being the first discoverer of gold at Nullagine in 1886. A good deal of work must have been done at one time or another, but as operations have been abandoned for some considerable time there is little to be seen.

By far the larger portion of the hill appears to have originally been covered with a gritty and ferruginous sand (the residual decomposition product of a sandstone) underlaid by a kaolinic

deposit which carried waterworn boulders. It is noteworthy that while the material from the hill was being crushed several small diamonds were met with in the battery boxes; reference however will be made to this subject on a later page. The Cook's Hill deposit lies not very far from the base of the Nullagine Series. The total returns from the Cook's Hill workings, as shown in the table below, give the yield as being 140·10 ozs. obtained from the milling of 348 tons of ore, or at the rate of ·40 oz. per ton. In this return an effort has been made to credit Cook's Hill with the yield actually obtained from the ore raised.<sup>1</sup> The return from the Diamond Reward Claim, M.R.C. 6L, as shown in the general table at the end, is really the result of the ore obtained from the Cook's Hill workings, and there seems to be good reason for believing the 1899 return from the Success Lease 27L includes 96 tons of ore from this same source. This latter yielded a return of 34·40 ozs. of gold, or at the rate of ·36 oz. per ton. The workings on Beaton's Hill, which lie to the west of those last described, the hill upon which work has already been carried out, comprises about 4 acres, and is covered by a deposit of laterite stated to be about 10 feet in thickness. Beneath the laterite occurs a more or less variable thickness of almost horizontal beds of sandstone and conglomerate. The bed which was worked lies near the base of the hill, and is said to rest directly upon a bedrock of slate, and the gold is said to have been traced thereto by the alluvial workers in the adjacent gully on the north.

Two shafts, now inaccessible, have been sunk to depths stated to be 35 and 40 feet respectively, and levels driven therefrom.

*Table showing the Yield of the Conglomerates of the Mineral Reward Claim 6L.*

Year.	Name of Lease.	Ore Crushed.	Gold therefrom.	Rate per Ton.	Total Ore Crushed.	Total Gold therefrom.	Average Rate per Ton.
		Tons.	Ozs.	Ozs.	Tons.	Ozs.	Ozs.
Previous to 1897	Golden Crown, G.M.L. 31L	32·60	50·90	1·56			
1898 . .	„ „	191·00	139·00	·72	223·60	189·90	·84
1898 . .	Cook's Hill, G.M.L. 47L	22·00	26·30	1·19			
1899 . .	„ „	96·00	34·40	·36			
1900 . .	„ „	230·00	79·40	·34	348·00	140·10	·40
Total . . . . .					571·60	330·00	·49

<sup>1</sup> The late Mr. Becher's note-book, 1896, states that "since first worked Cook's Hill has yielded about 4000 ozs. of gold." There is no reason for doubting the accuracy of this statement, but it is quite clear that this amount has not been officially recorded in the statistics, and may possibly never have been reported to the Government.



Mr. Beaton, one of the original holders of the ground, and after whom the hill is named, is stated to have worked a considerable distance in under the hill, and to have taken out a large quantity of gold by crushing the material roughly by hand, screening it, and sluicing it at the river. There appears, however, to be no official record of the yield from the old Beaton's Hill Lease, and in all probability any returns therefrom have been included in that from Sundry Claims.<sup>1</sup>

GOLDEN PROMISE, G.M.L. 380 (39L, and subsequently Golden Promise No. 1 67L).—The abandoned workings upon what was originally embraced by this lease are coterminous with the north-western boundary of the Mineral Reward Claim, 6L (Plate VIII.), and at an altitude of about 180 feet above the general level of the plains. A vertical shaft, 20 feet in depth, had been put down through conglomerate and intersected the open-works at a lower level. The auriferous portion of the conglomerate was a ferruginous band varying from 15 inches to 2 feet in thickness.

The following table gives the yield of the crushings:—

*Table showing the Yield of the Golden Promise Conglomerate.*

Year.	Ore Crushed	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1897 . . . . .	84·00	68·65	·81
1898 . . . . .	88·00	81·20	·92
Total . . . . .	172·00	149·85	·87

SUNDRY CLAIMS FROM THE DISTRICT GENERALLY.—In addition to the returns given above in connection with Sundry Claims, which it is impossible to specify individually, there have been recorded over 6000 ozs. of gold. These figures are given in such detail as is possible in the table below. There are, however, no means of ascertaining what proportion of these figures are to be credited to that portion of Nullagine embraced by the geological map (Plate VIII.); it is, however, possible that they include returns from the Elsie, Mosquito Creek, Nullagine, and 20-mile Sandy, which centres are included in the "Nullagine District," as defined by the Mines Department.

### Diamonds

The occurrence of small diamonds at Nullagine having been brought under the notice of the Government, a report was obtained on the subject by the then Premier from Mr. Fred F. Groom in the

<sup>1</sup> The late Mr. Becher's note-book, 1896, states:—"Return, September 1896, 1 ton, yielding 2 ozs. 2 dwts. 12 grs. Since Beaton's Hill was first worked it has yielded about 3000 ozs. of gold." This amount does not appear to have been officially recorded in the statistics, and may possibly never have been reported to the Government.

01.	1902.		1903.		1904.		Total.	
Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.
Ozs.	Tons.	Ozs.	Tons.	Ozs.	Tons.	Ozs.	Tons.	Ozs.
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	998'00	943'10
614'53	300'00	128'51	777'00	94'10	..	..	2,435'00	837'14
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
33'00	..	..	..	..	..	..	643'00	574'65
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	338'00	351'25
..	..	..	..	..	..	..	20'00	25'00
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	223'60	189'90
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	172'00	149'85
..	..	..	..	..	..	..	22'00	26'30
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	85'40	40'70
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	230'00	79'40
647'53	300'00	128'51	777'00	94'10	..	..	5,167'00	3,217'29

*Table of the Yield of the Auriferous Conglomerates at Nullagine.*

Name of Lease.	Number of Lease.		Owner.	Remarks.	Prior to 1897.		1897.		1898.		1899.		1900.		1901.		1902.		1903.		1904.		Total.	
	Marble Bar Number.	L. Number.			Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.	Ore Crushed.	Gold therefrom.
Freak of Nature . . .	208	1	N.W. Australian G.F's., Ltd.	Now 120, 121 . . . . .	Tons.	Ozs.	Tons.	Ozs.	Tons.	Ozs.	Tons.	Ozs.	Tons.	Ozs.	Tons.	Ozs.	Tons.	Ozs.	Tons.	Ozs.	Tons.	Ozs.	Tons.	Ozs.
Success Extended . . .	..	120	British Exploration of Australasia, Ltd.	In force. Late 1, 21, 27, M.L. 1, and M.L. 9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
The Trinity (Grant's Hill)	216	2	N.W. Australian G.F's., Ltd.	Now 122, 121 (small portion)	109 00	147 00	..	..	275 00	382 35	462 00	343 25	152 00	70 50	..	..	..	..	..	..	..	..	998 00	943 10
Grant's Hill . . . . .	..	122	British Exploration of Australasia, Ltd.	In force. Nearly all 2L, and part of M.L. 1	..	..	..	..	..	..	..	..	..	..	1,358 00	614 53	300 00	128 51	777 00	94 10	..	..	2,435 00	837 14
Exchange . . . . .	279	18	N.W. Australian G.F's., Ltd.	Greater part in 121 . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Freak of Nature . . .	..	121	British Exploration of Australasia, Ltd.	Portion of 1, 2, 18, 21, M.L. 1, and whole of Q.C. 6L. In force	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Freak of Nature Extd.	310	21	N.W. Australian G.F's., Ltd.	In 120 and 121	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Success . . . . .	352	27	N.W. Australian G.F's., Ltd.	Late 219-5L. In 119 and 120	32 00	43 00	..	..	305 00	349 25	206 00	149 40	..	..	100 00	33 00	..	..	..	..	..	..	643 00	574 65
" . . . . .	..	119	British Exploration of Australasia, Ltd.	In force. Portions of 27L and M.L. 9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Barney's Hill United . .	276	16	A. S. Roe . . . . .	Abd., 5/8/97. N.N.W. of 27L	80 00	100 15	246 00	228 00	12 00	23 10	..	..	..	..	..	..	..	..	..	..	..	..	338 00	351 25
Barney's Hill No. 1 N.	330	24	" . . . . .	Abd., 5/8/97. N.W. of 16L	20 00	25 00	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	20 00	25 00
Rejected . . . . .	414	48	" . . . . .	Abd., 5/8/97. S.W. of 16L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Rejected, No. 1 . . .	415	49	" . . . . .	Abd., 5/8/97. N.W. of 48L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Golden Crown . . . .	365	31	Conglomerate G.F's. of W.A., Ltd.	Cancelled, 14/10/98. S.E. of 27L. In M.R.C. 6L	32 60	50 90	..	..	191 00	139 00	..	..	..	..	..	..	..	..	..	..	..	..	223 60	189 90
Beaton's Hill. . . . .	373	37	Conglomerate G.F's. of W.A., Ltd.	Cancelled, 14/10/98, 5 chns. S.E. of 69L. In M.R.C. 6L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Golden Promise . . .	380	39	Eatch, Lynch, Reyes, &c.	S. of 31L. Later 67L . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Golden Promise, No. 1	..	67	Conglomerate G.F's. of W.A., Ltd.	Late 39L. Cancelled, 14/10/98. Part in M.R.C. 6L	84 00	68 65	..	..	88 00	81 20	..	..	..	..	..	..	..	..	..	..	..	..	172 00	149 85
Cook's Hill . . . . .	412	47	Conglomerate G.F's. of W.A., Ltd.	Includes 36L. S.E. of 21L. In M.R.C. 6L	..	..	..	..	22 00	26 30	..	..	..	..	..	..	..	..	..	..	..	..	22 00	26 30
Trinity No. 1 South . .	422	54	Owen Connolly . . . .	Later 68L. S.E. of 2L .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Grant's Hill South . . .	..	68	Conglomerate G.F's. of W.A., Ltd.	Late 54L. Cancelled, 17/2/99	..	..	..	..	..	..	85 40	40 70	..	..	..	..	..	..	..	..	..	..	85 40	40 70
Nullagine Central . . .	..	45	Butler, Ramsay, and Skinner	Later 69L. S.E. of 31L .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Central No. 1 . . . . .	..	69	Conglomerate G.F's. of W.A., Ltd.	Late 45L. Cancelled, 14/10/98. Part in M.R.C. 6L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Rejected No. 2 . . . .	416	50	A. S. Roe . . . . .	Abd., 5/8/97. Adjoins 47L on East. Later part in 73L. In M.R.C. 6L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Diamond Reward Claim	..	M.R.C. 6L	British Exploration of Australasia, Ltd.	Takes in 31L, 37L, 47L, 50L. Part of 67L and 69L	..	..	..	..	..	..	..	..	230 00	79 40	..	..	..	..	..	..	..	..	230 00	79 40
Total . . . . .					357 60	434 70	246 00	228 00	893 00	1,001 20	753 40	533 35	382 00	149 90	1,458 00	647 53	300 00	128 51	777 00	94 10	..	..	5,167 00	3,217 29



*Table showing the Yield from Sundry Claims, Nullagine.*

Year.	Ore Crushed.	Gold therefrom.	
		Tons.	Ozs.
1897 . . . . .	100·00		143·65
1898 . . . . .	92·60		213·90
1899 . . . . .	1,066·70	{	2,695·95
			138·45
1900 . . . . .	1,008·60	{	2,433·30
			111·00
1901 . . . . .	248·25		336·54
1902 . . . . .	293·05		343·67
1903 . . . . .	145·90		609·30
1904 . . . . .	830·65	{	1,308·65 <sup>2</sup>
			123·75 <sup>2</sup>
Total . . . . .	3,785·15		8,158·16
			2·15

year 1896.<sup>3</sup> From Mr. Groom's report it appears that the greater number of the most valuable diamonds were washed out of the conglomerate forming Brook's Hill, which was being treated for gold, and others were found in the stamper boxes after crushing a few tons of the conglomerate. Mr. Groom states: "There is no doubt, in my opinion, that the diamonds are enclosed in the conglomerate, . . . and such as have been found by diggers in washing for gold have been released by the gradual decay of the rock. . . . On the last day of my stay in Nullagine, I was present at the cleaning up of the battery after crushing about two tons of stone taken from the hill. . . . On carefully panning off the gravel left in the stamper boxes nine small stones were found, varying from the size of a pin's head to a pepper-corn, or from  $\frac{1}{16}$  to  $\frac{1}{2}$  carat in weight. I put the lot into the scales, they weighed  $1\frac{1}{2}$  carats, and it took the four largest to weigh one carat. I was informed that Mr. Brooks found one diamond for which he obtained £76, another he sold for £28. These, with one other valued by the finder at £12, were all the diamonds I could hear of as having been of any value; the last-mentioned stone was described as being bright yellow."

During the course of my examination of the district no diamonds came under my notice; there are, however, in the collection of the Western Australian Museum (a) four small diamonds presented by Messrs. Brook Bros. in 1896, and (b) four small diamonds taken from the battery boxes when cleaning up a crushing of conglomerate, one from Cook's Hill, presented by Mr. Inspector S. J. Becher in 1896. The returns of a crushing of

<sup>1</sup> Specimens.<sup>2</sup> Fine ozs.<sup>3</sup> Report of a visit to Nullagine, Pilbara District, to examine the country reported to be diamond-yielding. Appendix 4. Report of the Department of Mines for the year 1895. Perth: By Authority, 1896, p. 27.

230 tons of conglomerate from the Mineral Reward Claim 6L in 1900 show, in addition to 79·40 ozs. of gold, twenty-five small diamonds, the value of which, however, is not stated. From the particulars given above it seems perfectly clear that the presence of diamonds in the conglomerates near the base of the Nullagine Series is authentic. The occurrence of such renders it possible that they are not isolated instances, though the interest is at the present time more scientific than commercial.

### K.—Warrawoona

*(With a Geological Sketch Map and three Mine Plans. Plates X. to XIII.)*

#### GENERAL GEOLOGY

The mining centre of Warrawoona lies about 15 miles from Marble Bar, and embraces the south-eastern extension of that belt of auriferous rocks which form the Marble Bar, Yandicoogina, and Mount Elsie Zone, to which reference has been made in a previous report.<sup>1</sup>

The district of which Warrawoona is the centre is formed of a lofty serrated razor-backed ridge (with several minor parallel ones) trending generally north-west and south-east. It is upon the southern slopes of the main ridge, and what perhaps may be conveniently called the foothills, that all the auriferous quartz reefs occur. The general trend of these ridges has been determined by the outcrop of the siliceous rocks of which they are everywhere made up.

Several important watercourses occupy the longitudinal valleys (carved out of the softer strata) between the different ridges, whilst those creeks which breach them almost at right angles to the general strike of the schists afford many excellent sections. They thus shed light upon many obscure points in connection with the geological features of the district. The plateau which extends for miles on either side of what may be called the main axis owes its relatively smooth and rounded contour to the general homogeneity and practically equal weathering of the rocks by which it is underlaid, *e.g.* granite, &c.

The geological formations of the area embraced by the geological sketch map of Warrawoona (Plate X.) are represented by a series of sedimentary rocks, quartzites, and conglomerates, many of which have been converted into quartz schist, mica schist, &c., by dynamic agencies. Associated with these undoubted sedimentary strata are a series of igneous rocks which have likewise been rendered partly schistose by the same causes. The exact relation these igneous rocks bear to the sedimentary series has not been worked out, a problem which would perhaps be difficult in this particular portion of the district. The southern portion of the district

<sup>1</sup> Bulletin No. 15, p. 33 *et seq.*





GEOLOGICAL SKETCH MAP  
OF

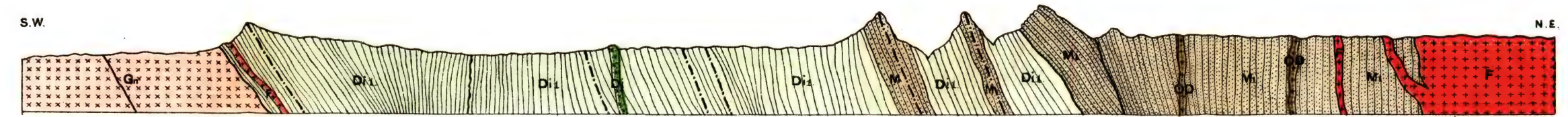
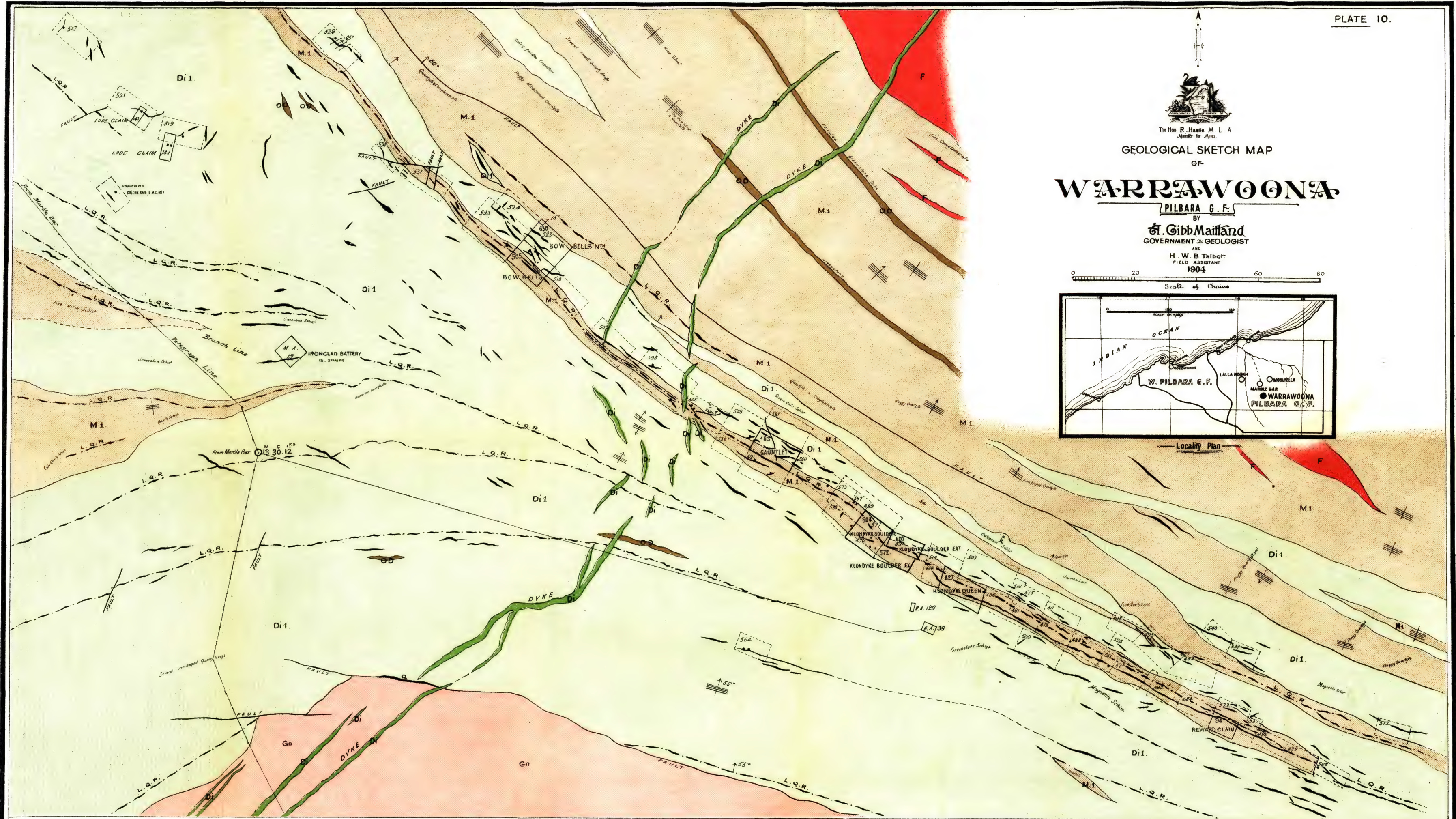
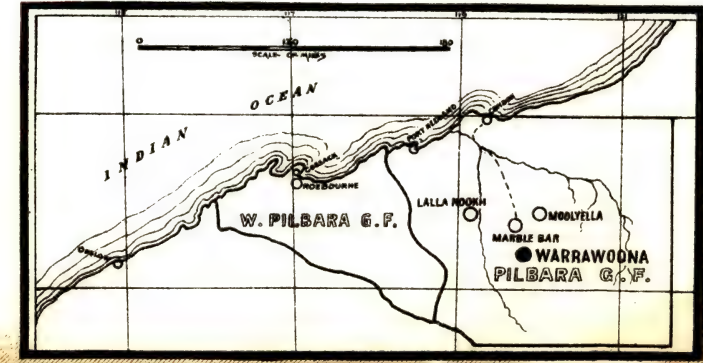
# WARRAWOONA

PILBARA G. F.

BY  
**J. Gibb Maitland**  
GOVERNMENT GEOLOGIST

AND  
H. W. B. Talbot  
FIELD ASSISTANT

1904

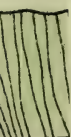
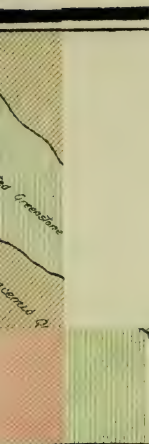


GENERALISED SECTION ACROSS WARRAWOONA.  
LENGTH OF SECTION ABOUT THREE AND A HALF MILES. NOT DRAWN TO SCALE.

## EXPLANATION OF COLOURS AND SIGNS

QUARTZITE, CONGLOMERATE, QUARTZ SCHIST, MICA SCHIST & ALLIED SEDIMENTARY ROCKS...	M1
GREENSTONE, MAGNETITE, SERPENTINOUS SCHIST & ALLIED IGNEOUS ROCKS.....	Di 1
GRANITE.....	Gn
FELSITE & FELSPAR PORPHYRY.....	F
BASIC DYKES { NEWER OLDER	Di OD
Quartz Reefs.....	Laminated Quartz Reefs
Mining Leases { NAME OF NO. OF	GAUNTLET 483
Machine Area..... M. A.	Business Area..... B. A.
Dip of Strata.....	Geological Boundaries.....
	Residence Area..... R. A.





AC  
ND A H



is occupied by granite, which appears to have been brought into position by a fault, trending generally north-west and south-east.

Somewhat akin to the southern granitic mass are those dykes and masses of felspar-porphyry which occupy the northern limits of the map; in all probability these latter have some intimate connection with the large area of granite which occupies the country to the north of that embraced by the Warrawoona map. There seems, however, to be strong reasons for believing the granite to be intrusive into what may conveniently be termed the schists, and that portions of it have been affected by earth movements of varying degrees of intensity after the intrusion took place.

In addition to these rocks, the field is traversed by a remarkably persistent series of north-west and south-east greenstone dykes. These dykes, which have been mapped with some degree of accuracy, traverse the centre of the auriferous portions of Warrawoona, approximately at right angles to the general trend of what may be called the auriferous zone. Besides these relatively newer greenstone dykes, there are others which are intimately associated with the older rocks of the district. These older dyke rocks are often rudely cleaved and foliated, and seem to occur in intimate connection with, or parallel to, the principal structural lines of the district, viz., north-west and south-east. These older cleaved or foliated dykes can be seen in many places to be pierced almost at right angles to their general trend by the newer or uncleaved series.

Within the area embraced by the map, there is a large development of those laminated or banded quartz veins which form such conspicuous features in this district. These, owing to their economic importance, have been laid down upon the map with a considerable degree of accuracy. One conspicuous band traverses the whole length of the district, viz., 6 miles, and forms the centre of the main auriferous zone, which latter is of considerable longitudinal extent, though averaging only about 20 or 30 chains in width.

Of the different rocks occurring in the Warrawoona area, not much can be said, in the present state of our knowledge, of their relative ages, nor their true position in the geological time scale.

The following is a list of the various rock groups arranged in tabular form :—

Warrawoona Beds.	Age	(a.) Altered Sedimentary Series (quartzites,
undetermined (? Arch-		conglomerates, quartz, and mica-
æan)		schist, &c.)
		(b.) Metamorphic Igneous Rocks (green-
		stone, magnetite, and serpentinous
		schist, and more or less allied sheared
		basic igneous rocks)
Granite and Felspar Porphyry.		
Basic Dykes	(a.) Newer	
	(b.) Older	

### Warrawoona Beds

The strata of the Warrawoona Series form part of that auriferous zone which includes Marble Bar, Yandicoogina, and Mount Elsie, and to which reference has already been made in a former report.<sup>1</sup> In the Warrawoona neighbourhood, however, much better opportunities for investigating the strata present themselves than in any other portions of the district yet examined.

An examination of the district, which is of great importance, by reason of its gold yield, shows that the Warrawoona Beds can be separated into two distinct portions sharply differentiated from each other, viz., an acidic and a basic series. The acid series is made up of highly siliceous beds, dipping at varying angles to the north-east and trending generally north-west and south-east. The beds, which there are very good reasons for believing to be of sedimentary origin, consist of fine-grained flaggy quartzites, sheared conglomerates which still retain traces of their original character, mica and quartz schists, together with certain other fine-grained siliceous rocks which seem to have lost all trace of their original character. There are, in intimate association with these, certain other acidic rocks, which may eventually prove, on closer examination, to be highly-sheared felsites; it has however not been found possible, owing to the small scale of the map, to delineate the area over which these doubtfully acidic igneous rocks extend; it is, however, but small.

In hand specimens, this doubtful rock [5788] is in reality a quartz-sericite schist, with eyes or lenticules of a fairly soft mineral around which the finer foliation of the matrix sweeps in very graceful curves. The mineral forming these eyes has been examined both chemically and microscopically by Mr. E. S. Simpson, who reports that "they appear at one time to have been single crystals of probably potash-felspar, but are now completely altered into a mixture of at least three minerals, viz., free quartz; a non-hydrous crystalline silicate of alumina, probably andalusite; and a hydrous silicate of alumina and alkalies, probably a mica. The specific gravity of these 'eyes' is variable, but averages 2.85. Their average composition is:—

Silica, $\text{SiO}_2$ . . . . .	76.0
Alumina, $\text{Al}_2\text{O}_3$ . . . . .	21.4
Ferrous Oxide, $\text{FeO}$ . . . . .	.3
Lime, $\text{CaO}$ . . . . .	<i>Nil</i>
Magnesia, $\text{MgO}$ . . . . .	Trace
Potash, $\text{K}_2\text{O}$ . . . . .	.4
Soda, $\text{Na}_2\text{O}$ . . . . .	.3
Combined Water, $\text{H}_2\text{O}$ . . . . .	1.6
	<u>100.0</u> "

<sup>1</sup> Bulletin No. 15, p. 33 *et seq.*



Fig. 36.



*Photo: S. J. Bolter.*

Sheeted Zone in country rock, Warrawoona, Pilbara Goldfield.







Fig. 37.



*Photo. : S. J. Becher.*

**Enlarged view of Sheeted Zone in country rock, Warrawoona, Pilbara Goldfield.**

Examined under the microscope these porphyritic crystals are found to be shattered and broken, and their edges present that peculiar peripheral granulation so characteristic of crystals and fragments which have been subject to intense crushing. A micro-photograph of one of these shattered and broken crystals forms A 1 Fig. 40. The matrix in which the larger crystals are embedded presents a fine mosaic of quartz, felspar, and a little sericitic mica through which are streams of numerous yellowish brown crystals. These crystals which occur in the form of short, and sometimes geniculated, pear or kite-shaped prisms, with straight extinction under crossed nicols, are in all probability rutile. It is difficult, with the evidence at present available, to be sure of the exact nature of the original rock, but it may possibly have been produced by the crushing of a felspar porphyry. Unaltered felspar porphyries do occur in the country just to the north of this, hence it is possible that this rock may be merely a transmitted variety of them.

The specimen, a quartz sericite schist [5760], is another variety of a rock identical in many respects with that last described, except that there are no large porphyritic crystals. Streams of rutile are common, in addition to numerous colourless acicular crystals of what seem to be apatite.

A quartz schist [5761] from near the Ironclad Battery, M.A. 1, consists microscopically of a mass of irregular interlocking grains of quartz, with irregular patches arranged in the form of bands, of what under crossed nicols is neither more nor less than a fine quartz mosaic. The quartz exhibits undulose extinction. A little sericitic mica occurs in places.

Another quartz schist [5762] from a different portion of the mass, when examined under the microscope consists of a very fine-grained mass of quartz, showing undulose extinction, together with a little sericitic mica, the foliæ of which are often very much distorted.

A fairly fine-grained quartzite [5764] which under the microscope is found to contain numerous fairly large angular and sub-angular quartz grains set in a much finer-grained quartz mosaic. This rock contains numerous brown patches and strings of mica (?) together with a little pyrites.

Associated with these quartzites and quartz schists is a very calcareous rock [5765] which outcrops near the Ironclad Battery. In hand specimens the rock is of a pale salmon colour, is distinctly banded, weathers very much like a limestone, and effervesces briskly upon the application of dilute acid. An analysis of this rock is given in the table on page 164. Very little can be made out by microscopic examination, even with a  $\frac{1}{4}$ -inch objective, and it is not quite clear whether the rock is a limestone or merely an extreme phase of the alteration of one of the igneous rocks of the district. The field relations, however, seem to point to its being distinctly interbedded with the quartzites and quartz sericite schists.

A short distance north of the Seven Dials, just outside the

limits of the geological map, is a conspicuous hill forming the western extremity of a bed of metamorphic grit (or quartzite) and conglomerate, dipping at angles averaging about 50 degrees to the north-east; the quartzite rests upon greenstone schist, and has been affected by the same foliation which affects the latter. The quartzite is traversed by bands of laminated quartz of the type prevailing in the district. Most of the pebbles in the conglomerate are flattened out almost beyond recognition, though in some places they are well shown on the weathered surface of the rock.

Among the quartz schists which form the summit of what may be called the main range of Warrawoona is a bed which here and there contains what at first glance appears to be fossil wood [5766]. A characteristic specimen of this silicified wood (?) has a length of about  $4\frac{1}{4}$  inches; cross sections of it are ellipsoidal in shape, the major axis being about three-quarters, and the minor axis about five-eighths of an inch in length. Microscopical sections both transverse and longitudinal were prepared, and were submitted along with the specimen to Mr. Etheridge of the Australian Museum, Sydney, who was unable to detect any trace of organic structure in them. It is, however, quite possible that the dynamic metamorphism which these rocks have undergone may have entirely obliterated all traces of organic structure, and that some form of plant life existed at the time these beds were deposited.

Adjoining Lease 479, the Juneau, is a schist forming part of the main series which presents many points of interest.

In hand specimens the rock [5787] is of a very light brownish colour, and is distinctly foliated. In addition to quartz, which forms no inconsiderable portion of the rock, there are numerous elongated crystals of a clear glassy mineral, the cleavage faces of which are very distinctly marked, and which give a distinctive character to the rock. Under the microscope the rock is found to be made up of clear and unaltered fragments of felspar, very few of which however are twinned, quartz polarising in brilliant colours, a little colourless mica and a reddish brown substance, which may result from the alteration of some mineral rich in iron. The rock is clearly a felspathic schist, the field relations of which point to its being of elastic origin.

The greenstone schists and other allied rocks of Warrawoona occupy a large area of country, and vary very much in the width of their outcrop. It is of course possible that this may in part be due to differences in the folding (?). A feature in the physical structure of the greenstone schists which may have some significance is what may be called an anticline of foliation, the centre of which trends generally in the same direction as the main structural lines of the district. This is well exposed at a point a little distance to the south of the Gauntlet No. 3 North-West Lease.

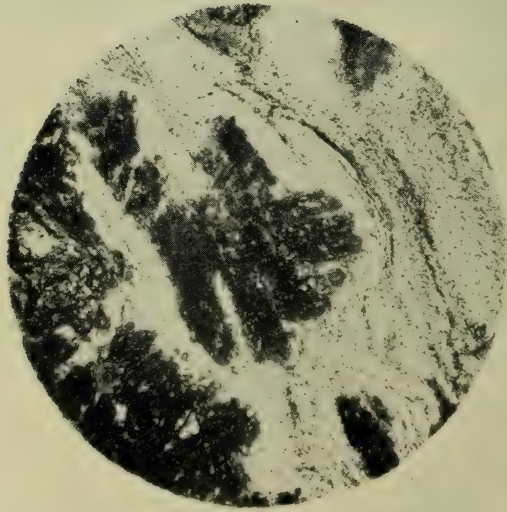
A very important feature of these greenstone schists is the presence among them of unfoliated basic rocks, which sometimes occur in the form of lenticular belts of (in certain places) con-





Fig. 40.

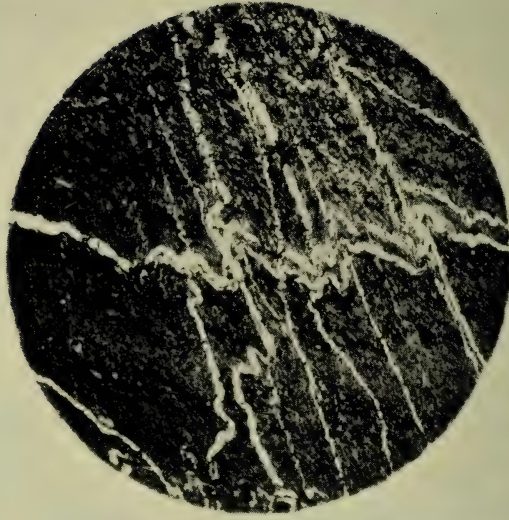
(A.)



*Photo.: E. S. Simpson.*

Broken Crystals of Feldspar (?) in sheared Feldspar-Porphyry [5788], Warrawoona. Enlargement, 11 diameters.

(B.)



*Photo.: E. S. Simpson.*

Section of Quartz Schist [5789] showing contorted quartz laminae in relation to stratification and cleavage foliation, G.M.L. 560, Warrawoona. Enlargement, 11 diameters.

siderable horizontal extent. Several excellent sections in the district show these basic rocks passing by scarcely perceptible gradations into the greenstone schists.

It is possible that as the strike of these belts of massive basic rocks more or less coincide with that of the general foliation of the district, they may occasionally be mistaken for some of the older basic dykes, which have a parallel strike.

In one or two localities are belts of magnetic-schist, in the centre of some of which are uncrushed "eyes" (of large dimensions) of greenstone occurring in such a way as to indicate that the margins only of the mass have been crushed down into schist. Many of these schists contain very large quantities of magnetite, such as give a very distinctive character to the rock.

The foliated or sheared greenstones on the Gauntlet Lease contain large brown crystals [5767], a combination of cube and octahedron of iron ore, viz., limonite pseudomorphs after pyrites. Many of these crystals are about an inch in length. In other portions of the field, the surface of the unfoliated greenstone is strewn with similar limonite crystals. Some of the greenstones are very much decomposed, and some of the constituent minerals are largely replaced by carbonates, giving the rock a very characteristic weathered surface at first sight, very suggestive of the weathered surface of some limestone.

The chemical compositions of several of these greenstones and their allies is given in the table of analyses, page 164.

In mineralogical constitution the rocks present very many points of similarity.

The country rock [5755] of the Golden Gate Reef is a soft green talcose-chloritic schist, the chemical composition of which is shown in the table on page 164. The crystals of talc which are often of considerable length, have been, as may be seen under the microscope, broken and torn apart by the stresses and strains to which the rock has been subject. The exact relation of this schist to the surrounding greenstone cannot be precisely determined, as access to the underground workings of the mine was not obtainable.

The rock [5777] which forms the matrix of the Imperialist Reef is a fine-grained talc-chlorite schist, identical with that of the Golden Gate. The analyses of the two rocks present also many points of similarity.

The Tom Thumb Reef is enclosed in a fine-grained chlorite schist [5756] which, when examined under the microscope, is found to be made up of quartz, felspar, chlorite, and epidote (?). The chemical composition of this rock is given on the table on page 164.

The country rock [5768] forming the matrix of the May-be reef is of a somewhat similar character, and, as its field relations indicate, owes its origin to the compression of a massive greenstone. Its mineralogical constitution does not appear to differ in any very essential feature from the other schistose greenstones; its chemical composition is given in the table quoted above.



The Gauntlet Lease is traversed by a band of chlorite schist [5779] in many respects identical with that forming the Tom Thumb Reef. The chemical composition of this rock agrees very closely with some of the massive diabases of other portions of the field.

At a point about 10 or 12 chains to the north-east of G.M. Leases 531 and 593 is a lenticular mass of a serpentinous rock [5757], the chemical composition of which is set forth in the table of analyses on page 164. The mass has a length of about 20 and a maximum width of about 5 chains, whilst its longer axis is in a direction of north-west and south-east, parallel to the main structural features of the district.

A very large quartz reef outcrops in the centre of the mass, but does not extend into the surrounding rocks. The serpentine is enclosed in the mass of acidic rocks, but in such a condition that its original condition is not quite clear; there seem, however, grounds for believing it to have been brought into its present position by a fault.

The massive greenstones vary very much in grain; they all contain more or less hornblende (sometimes fibrous) and its alteration product chlorite, quartz, felspar, and calcite, together with an iron ore. Some, however, are very calcareous, and effervesce briskly on the application of acid.

Detailed petrographical examination of all these rocks has not yet been made, but it is hoped to approach this subject at a later date, as opportunity offers.

### Granite and allied Granitic Rocks

The granite, which is of the normal type, occupies a rudely triangular patch on the southern boundary of the map, about 200 chains in length and about 40 chains in maximum width. It, however, extends for many miles far beyond the limits of the map. There seems good reason for believing that the granite is intrusive into the greenstone schists, though its northern boundary, to the south of the Imperialist Reef, is marked by a fault.

The exposure on the hillside, a plan of which forms Fig. 35, reveals the relationship of the granite and greenstone schists to each other.

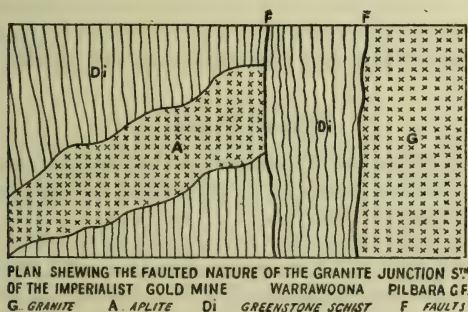
In this section the greenstone schists abut sharply against a smooth wall of granite, which is inclined at an angle of from 45 to 55 degrees to the north, this angle being practically coincident with the dip of the foliation planes of the schists. A few inches of schist separate an aplite dyke of 4 feet in thickness from the main granite mass. The dyke traverses the schists in a direction almost at right angles to their general strike. A quartz reef occurs along the faulted junction some distance east of this point, in close proximity to the newer greenstone dykes, which traverse the centre of the field. There is no very clear evidence of a marked banding or foliation in the granite anywhere in the

southern portion of the district. In that large granite mass on the north, just outside the limits of the map, it possesses a rude foliation or banding, which is parallel to the general strike of the foliation of the schists forming the higher ground to the south.

Whether this banding has any connection with the general foliation of the district, or is an original feature of the granitic magma, has not been satisfactorily determined. If this banding in the granite is not an original feature, then it would seem to indicate that both it and the Warrawoona beds were subject to the same set of stresses and strains which were set up in the interval separating the beds of the Nullagine from the older series.

The north-east angle of the map is made up of felspar-porphry [5792] sometimes occurring in the form of dykes. The rock, when a freshly broken and unweathered surface is examined, is found to be of a grey colour, with numerous crystals and fragments of a

FIG. 35.



cloudy white felspar (some of which show twinning) set in a fine-grained matrix.

Examined under the microscope, the rock is found to be made up of a micro-crystalline ground mass of quartz, together with a small proportion of orthoclase, in which are embedded large crystals and fragments of felspar, but no quartz. A relatively large quantity of biotite of a brownish colour occurs in many cases, arranged in bands which sweep round the porphyritic felspar in a manner paralleled by the flow structure developed in some volcanic rocks. The brown colour of the mica often passes gradually into a bright green, the result, probably, of alteration. The porphyritically developed felspar has not been optically determined, but the characteristic cross-hatched twinning in some parts would point to its being an orthoclase. The relatively large proportions of lime and soda as disclosed by the analysis [5792] shown in the table on page 164, would seem, on the other hand, to indicate that the felspar belongs to the lime-soda series. This felspar-porphry

is practically identical in its character with the Duffer's Creek porphyry referred to in the analysis [5392] of the rocks from Pilbara, on page 12 of Bulletin No. 15. There are few if any large porphyritically developed feldspars in this latter rock, which perhaps may be held accountable for the smaller percentage of potash and lime, as shown in the analysis; in all other respects the two rocks are identical.

There does not seem, so far, to be any intimate relationship subsisting between this porphyry and the main granite mass, as developed on either side of the main axis of Warrawoona. The fact that it shows no signs of even a quasi-foliation, which characterises some portions of the granite, would seem to indicate that the porphyry is of later date than the granite. It may, perhaps, have some connection with the volcanic activity which prevailed during the period of the deposition of the Nullagine Series.

The geological age of the granite cannot, as yet, be exactly determined; it is, certainly, newer than the Warrawoona Beds, into which it is intrusive. The granite passes beneath the Nullagine Series, which the evidence<sup>1</sup> so far available seems to point to being of Cambrian Age; in this case the granite would be Pre-Cambrian.

### Basic Dykes

The basic dykes of Warrawoona belong to two different periods; the district, however, furnishes no satisfactory evidence as to the exact age of each set.

The newer basic dykes traverse the whole width of the field in a general north-east and south-west direction, and extend for very many miles to the north and south of the country examined. The system of newer dykes intersects the auriferous belt between the Bow Bells and the Gauntlet groups of reefs almost at right angles to the general trend of the series. In no case do these dykes attain any great thickness, and their breadth varies greatly in different parts; the thickness, as shown on the geological map of Warrawoona (Plate X.), has been somewhat exaggerated, in consequence of the small scale employed. Such few cross sections as may be seen of them indicate that they approach very closely to the vertical.

The rocks of which they are composed are basic compounds; an analysis of the most typical [5773] is shown in the table on page 164.

In hand specimens these dyke rocks vary from coarse to medium grain, and are seen to consist of a greenish grey feldspar, together with a ferro-magnesian constituent and an iron ore. Under the microscope the rock is found to consist of allotriomorphic crystals of a plagioclastic feldspar, many of which present that turbid mealy aspect so characteristic of alteration, together

<sup>1</sup> *Supra*, p. 130.



with brown or almost colourless augite, and a little enstatite (?) passing into bastite (?). The place of some of the augite is taken by a pale green fibrous decomposition product which may be chlorite. The iron ore, which is often represented by skeleton crystals, is probably ilmenite. The rock is therefore a diabase.

The regular continuity of the system of dykes has been interrupted in the vicinity of their intersection with the auriferous series. From the position in which this interruption occurs, it would seem that these newer dyke rocks had undergone considerable movement since their injection. The somewhat curved and distorted fragments or isolated patches all point to a series of later movements along lines parallel to that of the main trend of the auriferous belt of Warrawoona.

The older series of dykes have a general trend approximately at right angles to that of those previously described, and are in some cases intersected by them. Like the newer dykes they are all basic compounds. In some cases they have been crushed and sheared into a schistose greenstone, which occasionally takes the form of a schist which has a characteristic weathered outcrop, very suggestive of a calcareous schist. These sheared dykes are all indicated upon the map.

### Fissures, Faults, &c.

A very marked feature in the structure of Warrawoona is the occurrence of those bands of laminated quartz which traverse the whole length of the field, these being locally spoken of as "dykes."

These bands often rise in the form of rough serrated ridges, which, by virtue of their power of resisting denuding agencies, stand out in bold relief, and can be followed across country for, in some cases, miles. They are, wherever seen in section, either vertical or inclined at high angles to the north-east. In the case of the crosscut from the south drive in the tunnel workings of the Bow Bells Mine (Plate XI.), a dip of 65 degrees was observed. Although this vein, as seen underground, proved to be 10 feet in thickness, there did not appear to be any distinct line of demarcation between it and the country rock, the whole section in the crosscut suggesting a gradual replacement of the original rock along lines of maximum compression or foliation.

Similar cases of a gradual transition between the quartz and the country rock can be noticed in several cases along the summits of the ridges in the district.

Of these bands there are twelve in all, the most conspicuous and the most important being that which traverses the whole line of leases across the field in a north-westerly direction. This particular vein is locally spoken of as "The Dyke," and it may be that it represents an old line of weakness along which disturbance has taken place at several distinct periods.

The other veins, it will be noticed, all taper off gradually along a line which is, approximately, parallel to the dyke, and are dis-

*Table of Analyses of Rocks from Warrawoona.*

BY E. S. SIMPSON.

Geological Museum No.	5755	5756	5757	5765	5768	5773	5777	5778	5779	5780	5781	5792	5793
Specific Gravity	2.94	2.88	2.91	2.76	2.79	3.00	2.93	2.82	2.62	2.84	2.58	2.73	3.07
Silica, SiO <sub>2</sub>	43.25	43.47	30.63	17.63	41.88	50.48	43.90	45.68	55.00	48.54	65.75	69.14	50.20
Alumina, Al <sub>2</sub> O <sub>3</sub>	9.98	14.87	1.68	4.28	10.13	23.18	9.13	8.94	24.30	13.67	19.39	14.71	17.95
Ferric Oxide, Fe <sub>2</sub> O <sub>3</sub>	1.93	3.35	5.94	1.97	Nil	3.07	1.20	2.23	3.93	2.13	.51	3.47	9.49
Ferrous Oxide, FeO	10.04	14.93	4.72	Nil	9.59	8.86	10.48	5.91	7.53	10.04	3.05	.78	4.20
Magnesia, MgO	22.48	12.64	32.30	14.74	7.20	.64	19.17	12.25	2.30	4.54	2.36	1.09	2.26
Lime, CaO	5.31	1.18	Trace	24.63	13.06	7.47	7.46	12.56	.18	6.46	Nil	4.83	7.76
Soda, Na <sub>2</sub> O	.49	.55	.41	.92	1.30	2.17	.57	1.82	2.43	3.58	.93	4.24	1.01
Potash, K <sub>2</sub> O	Trace	.13	.11	.43	.10	.83	.09	.12	Trace	.04	4.66	1.00	.14
Combined Water, H <sub>2</sub> O	4.74	6.82	.52	.70	3.51	1.71	4.68	1.92	3.14	2.74	1.78	.08	3.04
Hygroscopic Water, H <sub>2</sub> O	.20	.26	.15	.05	.07	.10	.04	.07	.27	.04	.10	.04	.10
Carbonic Anhydride, CO <sub>2</sub>	.17	Nil	23.03	34.94	11.60	.55	2.46	8.34	.98	7.14	.16	.40	1.12
Titanic Oxide, TiO <sub>2</sub>	.50	1.48	.52	.20	1.15	.38	.30	.40	Trace	1.12	.66	.30	1.42
Pyrites, FeS <sub>2</sub>	.03	.05	.09	Nil	.16	.14	.02	.04	Trace	.12	.11	Trace	.14
Manganese Protoxide, MnO	.04	.06	.11	Nil	.18	.16	.03	.05	...	.14	.12	...	.16
	.54	.10	.11	Trace	.32	Trace	.05	.09	Trace	Trace	Nil	.21	.37
Total	99.70	99.89	100.32	100.49	100.25	99.74	99.58	100.42	100.06	100.30	99.58	100.29	99.36

posed somewhat in the shape of a fan, the ribs of which open out gradually to the west.

The mode of occurrence and ending off of these quartz veins is very suggestive of this line being a fault; to which the interruption in the continuity of the newer diabase dykes in the vicinity would seem to lend additional colour. There is, however, no sign of any such fault on the surface, and, in fact, owing to the nature of the surrounding rocks, any such might readily escape detection.

These laminated quartz veins have been subject to a certain amount of faulting, and all those which have any effective throw have been laid down upon the map. As all the veins have a very high underlie, a considerable vertical displacement might easily take place without having any very marked effect upon the outcrop.

When examined under the microscope, typical specimens of these laminated quartz veins [5758, 5759] present no features of any particular moment.

In addition to the laminated quartz veins previously mentioned, there is another type of fracture developed on the field, which makes itself manifest in two well-defined bands, trending approximately parallel to them. These bands, which form a very pronounced feature in the landscape, are represented by a "sheeting" or "zoning" of the country rock, the width of which varies within very wide limits. The photographs, Figs. 36 and 37, taken by the late Mr. S. J. Becher, give a graphic idea of the nature of these zones, which in reality result from the powerful compression to which the rocks have been subjected. There are,

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- 5755.—Talc-chlorite schist. Golden Gate Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5756.—Chlorite schist. Tom Thumb Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5757.—Serpentine schist. Near Moolyella Gap, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5765.—Carbonated schist. Near Ironclad Battery, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5768.—Chlorite schist. May-be Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5773.—Newer Diabase Dyke. Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5777.—Talc-chlorite schist. Imperialist Lease, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5778.—Older Greenstone Dyke. Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5779.—Foliated Greenstone. Gauntlet Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5780.—Greenstone. Bow Bells Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5781.—Schist. Bow Bells Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5792.—Felspar-Porphry. North side of Main Range, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
  - 5793.—Greenstone. Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.



occurring in these bands, more or less extensive lenticules or "eyes" of quartz, parallel to the foliation; and many of these quartzes have a characteristic and distinct greenish hue [5759]. Fig. 38 shows a section across one of these compression fractures, with the characteristic quartz lenses, traversed by a reef of much newer formation. This newer reef is from 12 to 14 inches in thickness. The country rock traversed by this fracture has been silicified along the lines of compression, whilst the vertical slicken-sided faces indicate subsequent movement, which, however, may not have been very great. One of these bands of compression or

FIG. 38.



shearing traverses the whole length of the Klondyke Boulder Lease (Plate XIII.), parallel to the reef of the "Leader" type; it forms a very marked feature on the surface and stands out in bold relief. The foliæ, however, are not, in this section, vertical, but inclined at a very high angle to the north-east.

The faults which many of the reefs have undergone are referred to below under the heading of the Auriferous Deposits, and the position of those which can be actually observed and those the existence of which is inferred are shown upon the mining plans which form Plates XI., XII., and XIII.

## ECONOMIC GEOLOGY

## Auriferous Deposits

The auriferous deposits of Warrawoona are quartz reefs, which outcrop over a belt about 6 miles in length and about 20 chains in width.

There are no alluvial deposits of any extent anywhere within the limits of the area examined.

In addition to what may be called the main belt of Warrawoona, there are several minor outlying virtually isolated reefs, which have been worked in a more or less desultory fashion.

The position of all the quartz reefs has been laid down upon the geological map of Warrawoona (Plate X.) with such a degree of accuracy as the scale employed and a plane table survey would permit. No considerable body of ore, which is obvious to any one making a fair and reasonable inspection of the surface, has been overlooked. The reefs exhibit, when viewed on the whole, a general parallelism to the trend of the main structural features of the district. A careful examination of all the reefs, both on the surface and below ground, wherever such was possible, showed that they could be divided into two totally different types, which are sharply differentiated from each other.

The first type may, for convenience, be called the Normal or Fissure Vein Type, whilst the "Kidney" shaped lenticular quartz reefs of the second are locally spoken of as the "Leader."

Both types have been more or less opened up, and their relative importance as gold producers well established, as may be seen by a reference to the tables below.

Table showing the yield of—

(a) THE NORMAL QUARTZ REEFS OF WARRAWOONA.

*The Normal Quartz Reefs.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1898	.	.	.	.	626·85	3,143·72	5·01
1899	.	.	.	.	1,194·75	3,679·56	3·08
1900	.	.	.	.	1,854·31	4,973·74	2·68
1901	.	.	.	.	355·75	874·25	2·45
1902	.	.	.	.	396·55	774·80	1·95
1903	.	.	.	.	429·85	1,080·64	2·51
1904	.	.	.	.	105·45	236·44	2·24
Total					4,963·51	14,763·15	2·97

Table showing the yield of—

(b) THE LEADER TYPE OF DEPOSITS OF WARRAWOONA.

*The Leader Type of Deposit.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1898	.	.	.	.	78·55	276·75	3·52
1899	.	.	.	.	167·10	470·62	2·81
1900	.	.	.	.	87·40	314·45	3·59
1901	.	.	.	.	46·25	126·60	2·73
1902	.	.	.	.	49·70	147·26	2·96
1903	.	.	.	.	71·50	166·25	2·32
1904	.	.	.	.	49·00	125·38	2·55
Total					549·50	1,627·31	2·94

The data embodied in these two tables have been drawn up from the official statistics, but, of course, could not have been tabulated without a personal examination of the different reefs in the district. The figures demonstrate conclusively that whilst the average value of the two types of deposit is about equal, it is, however, the normal quartz reefs that have, up to the present, been most extensively worked, and the reason is not far to seek.

The reefs of the Leader type are in every respect identical with those described<sup>1</sup> as forming the important deposits in the mining centre of Edjudina.

At Warrawoona, the "Leader," which forms a continuous band, so far as prospecting operations have shown, of about two and a half miles in length, occurs along a line of rupture, which is forcibly shown by the powerful slickensided surfaces exhibited almost everywhere underground. These faces are often coated with fine films of gold. The "reef" is represented by "kidney" or damper-shaped lenses of quartz which vary from a few inches in width to a foot or two in length along the vein. The interval between each lens of quartz naturally fluctuates within very wide limits. Sections are visible in some of the workings fully described on a later page, which show the "casing" of the lens to be quartz of a somewhat different type; cases of this kind, which are of frequent occurrence along the "Leader" line, seem to point to the quartz lenses being portions of a pre-existing quartz reef which has been shifted in segments, as it were, along a vertical line of dislocation. Until these quartzes have been submitted to microscopical examination it is impossible to determine whether they exhibit optically any signs of mechanical strain, as would be naturally expected.

There seem very strong grounds for believing that the reefs of

<sup>1</sup> Notes on the country between Edjudina and Yundamindera, by A. Gibb Maitland, Bulletin 11. Perth: By Authority, 1903, pp. 14, *et seq.*

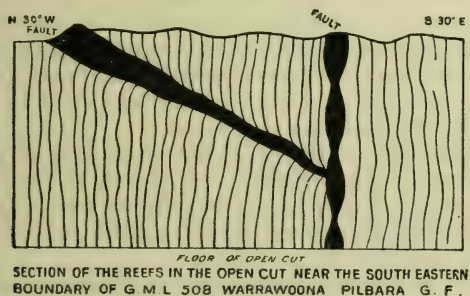


the "Leader" type are of later formation than those of the true fissure veins. Fig. 39 shows a section of a fissure vein abruptly cut off by the "Leader."

From the very nature of the Leader it is naturally somewhat difficult to work, as the stopes must be kept within the narrowest possible limits, and merely the auriferous quartz lenses extracted.

A feature of many of the normal reefs, notably those on the Bow Bells Lease, is the folding which they have undergone; this characteristic is particularly well exemplified in the case of the Horseshoe vein, and is shown on the plan which forms Plate XI. It will be noticed that in those cases in which the folding has taken place, there is almost invariably a relatively large pocket of ore at the apex of the arch. The fold in the Horseshoe vein of the Bow Bells Lease merely differs from the saddle reefs as depicted in many geological manuals in the fact that in this particular case the legs

FIG. 39.



are horizontal. Mining operations, however, have hardly been carried sufficiently far to determine whether or not the apices of the folds contain any higher grade ore than what may be called the legs of the reef. The fact that rich shoots are known to prevail in intimate connection with the apices of the folds in other mining districts where the quartz reefs have been violently contorted is a circumstance which should commend itself to the attention of those engaged in the exploitation of the reefs in question. All the evidence available points to the fact that the folding of the reefs is the result of great lateral pressure acting upon the country rock after the formation of the reefs themselves. The folding and puckering of some of the quartz veins is well illustrated, even in many hand specimens, notably in the quartz schist [5789] on the Gauntlet East, G.M.L. 560, a micro-photograph of which forms Fig. 40 B. This lateral pressure has not only folded but has faulted many of the reefs. Wherever possible the faults which have any effective throw have been mapped and shown in both the geological

and mining plans as well as in some cases in the sections by which they are accompanied. The high inclination of the majority of the veins is such as of course might permit of a considerable displacement without any marked effect upon the outcrop, hence many faults, unless disclosed during the course of mining operations, might easily escape detection. In the case of the main reef on the Gauntlet Lease, the rich shoot for which the mine is famed is coterminous with the fault which traverses the whole breadth of the lease. It is, however, not yet clear whether this fault fissure formed the channel along which the mineralising solutions percolated.

In addition to these normal vertical faults, there are also reverse faults or thrust planes, which are either horizontal or are inclined at a very low angle to the horizon. Typical instances of these are to be found in the workings on the Gauntlet and the Klondyke-Boulder leases; in the first of these cases the actual horizontal displacement measures only a few inches.

The reefs of both types are composed of a hard, translucent and crystalline quartz, which, in addition to the gold, contains in subordinate quantities pyrites, chalcopyrite, limonite, malachite, ferruginous wad, and a muscovite mica which is partly chromiferous.

In some cases the gold can be seen contained in cavities, evidently left by the oxidation of pyrites.

Cases have been observed of the occurrence of calcite [5776] carrying a trace of gold; possibly the parent source of the calcite is to be looked for in the lime-soda feldspars which enter into the composition of the greenstone and its allies, the country rock of many of the quartz reefs.

Although the total gold yield of Warrawoona has been 17,294·18 ozs., recovered from the milling of 5,700·01 tons of ore, thus giving an average value of 3·03 ozs. per ton, and many of the reefs have been opened up, these, however, have only been worked to very shallow depths.

All the mines which were open to inspection were visited, and full descriptions of them are given in the following pages. In the case of three properties—the Gauntlet, the Bow Bells, and the Klondyke Boulder, the reefs on which are instructive examples of the normal type as developed on the field—detailed surveys on a large scale of the various ore bodies, faults, &c., were made in the hope that they might in some measure furnish a guide as to the general behaviour of the reefs of this class in the locality. The result of these surveys has been embodied upon plans on the scale of 100 feet per inch accompanying the report, Plates XI., XII., and XIII.

For convenience of description, the mines and other workings are described in geographical sequence, commencing at the north-westernmost end of the field.

## THE MINES

PRINCEPT, G.M.L. 517.—This is the most north-westerly lease on the Warrawoona Belt. The ground is now abandoned, and so far as may be seen very little work has been done upon the property. The surface of the lease is occupied by greenstone-schist of the prevailing type.

Near the north-western boundary of the lease is a shaft of unknown depth, sunk upon a vertical reef of about 12 inches in thickness. The reef has a general north-eastern and south-western strike. So far as may be judged by the stone lying at grass the quartz [5754] contains oxide of iron, green carbonate of copper, carbonate of iron, together with a little red copper oxide. An assay of a characteristic sample [5754] of the ore yielded in the Survey Laboratory gold at the rate of 1 dwt. 15 grs. per ton.

In addition to this there are two other reefs on the property, situated near the south-eastern boundary, and lying about 300 feet apart. The westernmost and most conspicuous of these forms the summit of a very prominent rise on the ground, and, as measured at the top, is from 20 to 25 feet in thickness. So far as may be seen the reef is vertical, and strikes a little to the west of north. About 3 feet to the west of this is a parallel reef of ice-like quartz, but of no horizontal extent. The eastern reef, about 300 feet distant, extends some considerable distance southwards, beyond the confines of the property.

The following table gives the yield of this property. The gold was entirely derived from the reef in shaft above mentioned :—

*Table showing the Yield of the Princept Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1899. . . . .	Tons. 2·15	Ozs. 5·00	Ozs. 2·32

CUTTY SARK, G.M.L. 521.—Messrs. Skogsberg and Svensen. This property is an old lease, the Cutty Sark, which has been resurveyed, and part of it is now held as Q.C. 142. The reef worked on this lease has an average strike of 305 degrees, and appears to be the same as that which enters the property near the north-east angle of the lease.

A vertical shaft 74 feet in depth has been sunk by the present holders of the property, and the stone stoped out from a depth of 60 feet; the reef is said to have been 4 feet in thickness. From the bottom of the shaft crosscuts 6 feet in length have been put in east and west respectively. Owing to the state of the country rock it is stated that work had to be abandoned at this level. At the date this property was visited, access could not be obtained



below 33 feet from the surface; at this depth is a large body of quartz 5 to 6 feet thick; it is, however, merely a somewhat larger bulge on the reef than usual.

There are about 18 to 20 tons of quartz raised and awaiting crushing. The quartz at grass shows gold freely, it contains the red oxide, and the blue and green carbonates of copper in relatively small quantities, in addition to a little galena.

The only crushings from this reef were recorded in 1898 and 1904.

*Table showing the Yield of the Cutty Sark Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . .	4·75	10·10	2·12
1904 . . . .	31·30	49·00	1·56
Total . . .	36·05	59·10	1·64

TOM THUMB, Q.C. 128 (141).—Trangmar. This property was originally embraced within the boundaries of G.M.L. 519, the Carnoustie.

A good deal of work must have been done upon this property by the previous owners of the ground, but most of these workings are inaccessible at the present time.

A vertical shaft 94 feet in depth has been sunk through almost vertical beds of chlorite schist [5756].

At 65 feet is a level, which has been put in along the strike of the country for a distance of 40 feet to the west. The face of the drive connects with the old workings, the end of the rich chute being at this point, and the stone, merely thin lenticular veins along the foliæ, being stoped out to the surface from the westernmost old shaft.

*Table showing the Yield of the Tom Thumb Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1903 <sup>1</sup> . . . .	34·40	155·57	4·52
1904 . . . .	2·15	9·09	4·22
Total . . .	36·55	164·66	4·50

The quartz lenticules, of a totally different type to those occurring in Kopcke's leader, are said to attain a thickness of 12

<sup>1</sup> Previous to 1903 the yield was included under the heading of Sundry Claims. In 1898, however, the official statistics show that 45·40 tons of ore crushed from the Carnoustie reef yielded 178·11 ozs., or at the rate of 3·92 ozs. per ton. This, however, in all probability was obtained from the reef outcropping just outside the north-east angle of the claim, as shown in the geological sketch map of Warrawoona.

inches in places. At the foot of the main shaft a quartz reef was met with and a fairly large body of water was encountered, at the point at which the stone was first intersected. The water is standing in the shaft at 85 feet from the surface. From stone shown to me, it appears that the quartz lenticules must be very rich in places.

GOLDEN GATE, G.M.L. 607 (now Q.C. 137).—The unsurveyed quartz claim, 137, originally embraced by the Golden Gate Lease, G.M.L. 607, lies some little distance to the south of the Tom Thumb. The workings, however, are inaccessible; the main shaft is reputed to have reached a depth of 76 feet, and the reef stated to have consisted of lenticular quartz veins occurring along the planes of foliation of the talc-chlorite schist [5755].

*Table showing the Yield of the Golden Gate Reef.*

Year.		Ore Crushed.	Gold therefrom.	Rate per Ton.
		Tons.	Ozs.	Ozs.
1901	. . . .	6 00	} 16 40 16 00	2 73
1902	. . . .	13 00		2 24
1903	. . . .	40 45	73 00	1 80
Total . . .		59 45	118 50 1 6 00	1 99

SEVEN DIALS, G.M.L. 605.—The Seven Dials property, now abandoned, lies at the north-western extremity of what may be called the Bow Bells-Gauntlet Zone, as may be seen by an inspection of the geological sketch map of Warrawoona. (Plate X.)

The reef prospected enters the property near the north-western boundary, and, after a somewhat sinuous course, leaves it by the south-eastern boundary, not far from the north-east angle of the lease. So far as may be seen in an opencut on the surface, the reef underlays to the north-east at 65 degrees, and varies from 2 to 3 feet in thickness. The reef appears to be somewhat faulted along the outcrop, though the horizontal displacement is not more than 3 or 4 feet in each case. A vertical shaft (Fig. 41), 28 feet in depth, has been sunk at a point 34 feet north-east from the outcrop. The shaft has been carried down through a narrow belt of a fine micaceous schist.

CHANCE, G.M.L. 534.—This lease, now abandoned, occurs a few feet to the north-west of G.M.L. 531.

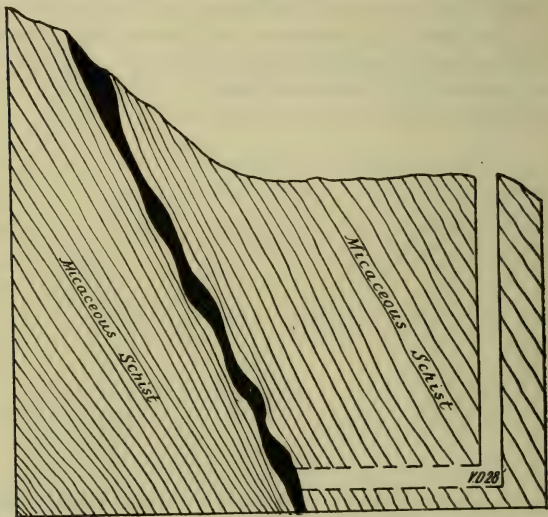
Work has been concentrated upon a somewhat similar deposit to that occurring in G.M.L. 531. At the outcrop the section across the vein from west to east is as follows: Quartz, 6 inches; formation, 8 inches; quartz, 12 inches; formation, 12 inches; quartz, 3 feet 6 inches. An underlay shaft has been put down to an

<sup>1</sup> Dollied and specimens.

unknown depth, but being inaccessible, no particulars as to the nature and behaviour of the reef underground are available. The quartz [5769] is almost pure white, and contains oxide of iron, small quantities of green carbonate of copper, and chalcedony.

Lying in the vacant triangular piece of ground between this

FIG. 41.



SECTION ACROSS THE SEVEN DIALS REEF G.M.L. 605 WARRAWOONA  
PILBARA G.F

lease and G.M.L. 531 is an underlay shaft, which has been put down to an unknown depth, upon a thin vein of quartz underlying northwards. Workings along the outcrop farther down the hill show the vein to attain a maximum thickness of 12 inches.

The returns of a small crushing in the year 1898 are shown in the table below.

Table showing the Yield of the Chance Reef.

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1898 . . . . .	Tons. 4·00	Ozs. 8·35	Ozs. 2·08

MAY-BE, G.M.L. 531.—This lease is abandoned, and no work had evidently been done upon it for some considerable time past. As may be seen by an inspection of the geological sketch map, it



will be noticed that the northern portion of the property is traversed by the main laminated quartz vein, which forms what may be called the backbone of Warrawoona; this quartz vein has been traversed by three faults which have had the effect of shifting the outcrop a few feet in each case. All the work on the lease centred on the quartz reefs occurring on the south side of the laminated quartz vein. On the summit of a hill near the south-west angle of the lease is an open cut, 20 feet in length, exposing about an inch of quartz encased in a banded (partly silicified) greenstone [5768], the foliation planes of which underlie at an angle of 60 degrees northerly. The quartz leader lies along a compression fracture which from its geological position may represent the north-western extension of Kopcke's leader.

BOW BELLS BLOCK No. 1, G.M.L. 524.—This is an old abandoned lease adjoining G.M.L. 523 on the north-west; it embraces a narrow strip of the northern portion of Bow Bells No. 1 West (*q.v.*). A few tons of stone have been crushed from this lease in 1898, as shown in the table; it is probable that this stone was raised from the reef in the inaccessible vertical shaft, of which mention is made in the description of the reefs on G.M.L. 593.

*Table showing the Yield of the Bow Bells Block No. 1 Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1898 . . . . .	Tons. 12·00	Ozs. 10·50	Ozs. ·87

BOW BELLS No. 1 WEST, G.M.L. 593.—An abandoned 24-acre lease adjoining the Bow Bells on the north-west. As may be seen by an inspection of the geological map, there are seven quartz reefs traversing the lease in addition to the main laminated quartz vein. The principal work has been done upon a reef outcropping near the northern boundary of the lease. A vertical shaft, now filled up, had been put down to an unknown depth on the slope of the northern wall of the valley, traversing the ground and connects with the surface lower down by a tunnel about 100 feet in length, driven on a bearing of 35 degrees. The face of the tunnel is filled with débris falling down the shaft, so that nothing whatever can be seen of the reef. The mouth of the vertical shaft shows a good solid body of quartz, varying from 2 to 4 feet in thickness. This stone in all probability represents the continuation of the large reef outcropping to the north of main shaft on the Bow Bells Lease, distant about 400 feet. At the mouth of the tunnel is a heap of quartz [5770] showing free gold, in addition to muscovite, which is partly chromiferous and partly stained by limonite, iron pyrites, and chalcopyrite.

Another reef outcropping 18 feet north of the laminated quartz

vein, forming the southern wall of the valley. The shaft is inaccessible, but as measured to the surface of the water at present standing in it, is at least 32 feet deep.

A little stone has been raised, and now lies at the mouth of the shaft. It contains [5771] muscovite, which is partly chromiferous, ferruginous wad, and limonite. The reef varies from 1 to 3 feet in thickness, and has such a strike as would carry it into the laminated quartz vein some distance to the west.

Bow BELLS, G.M.L. 505.—The Bow Bells Lease comprises an area of 12 acres, and was originally taken up by Messrs. Royer, Barnes, and Burroughs in the year 1898; it eventually passed into the hands of the present holders, the British Exploration Company of Australia, in 1901.

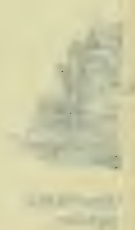
The lease, as may be seen by the geological sketch map of Warrawoona, lies in the same zone as that which embraces the Gauntlet Mine, G.M.L. 483, from which it is distant about 100 chains to the north-west. The surface of the lease is occupied by greenstone schists and allied rocks, and the southern boundary of the property is traversed by the band of laminated quartz, which extends across the lease from end to end.

As shown by the large scale plan of the mine (Plate XI.), there are seven reefs upon the property.

*The Northern Reef* (No. 3 shaft) extends along the surface for a distance of about 80 feet, and underlies at a high angle to the north-east; the thickness of the reef as showing at the surface is 12 inches. The shaft by which the reef is worked is 39.63 feet above the level of the main (or Horseshoe) shaft, and has been carried down to a depth of 45 feet 9 inches. The shaft was inaccessible, but I was informed by the manager (Mr. Hanemann) that at the bottom the reef proved to be small and poor. At a point about 50 feet north of the shaft, and along the outcrop of the same reef, is a shallow shaft, showing about 12 inches of quartz. No. 2 tunnel, 1.08 feet above the main shaft and 70 feet from it, was started with the object of intersecting the reef in No. 3 shaft, but after being carried in 8 or 10 feet, through country rock, it was apparently abandoned, and is now used as a store.

What may be called the *Horseshoe Reef* is worked from the main shaft, which has been sunk at the most convenient spot in the fork of the reef. The northernmost leg of the reef, as may be seen by the plan of the reefs (Plate XI.) can be followed for a distance of about 260 feet northwards, at which point it gradually tapers out to a thin vein of quartz, considerably less than an inch in thickness. At the bend of the horseshoe, the reef is about 5 feet in thickness. The southern leg of the reef can be followed, with a varying thickness, traversing No. 2 shaft, for a distance of about 150 feet, to a point at which it turns southerly, continuing on that course for a farther distance of 50 feet, whence it gradually disappears. The main shaft, which has been carried down 106 feet 2 inches verti-

PLATE I



SECTIONS

U.S. GOLD-MINE

U.S. GEOLOGICAL SURVEY

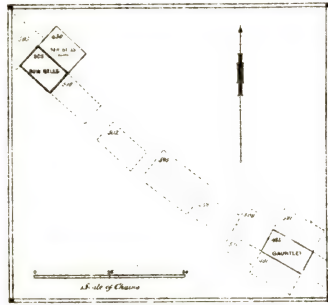
N. B. L.

W. B. L.

W. B. L.







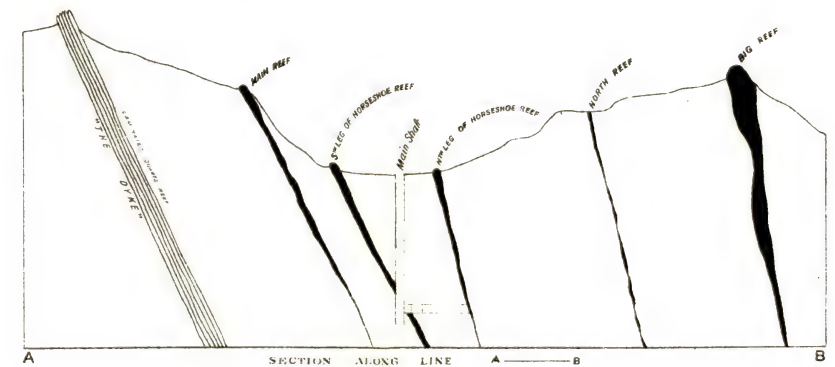
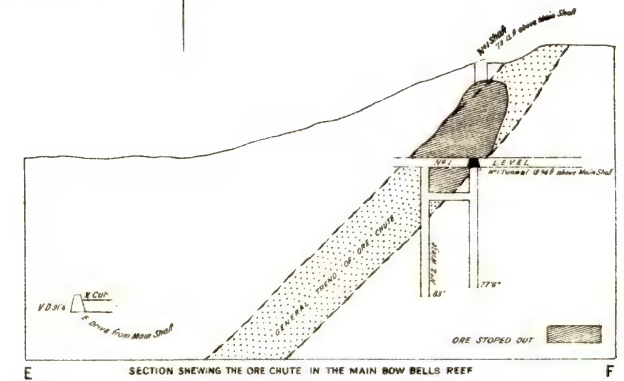
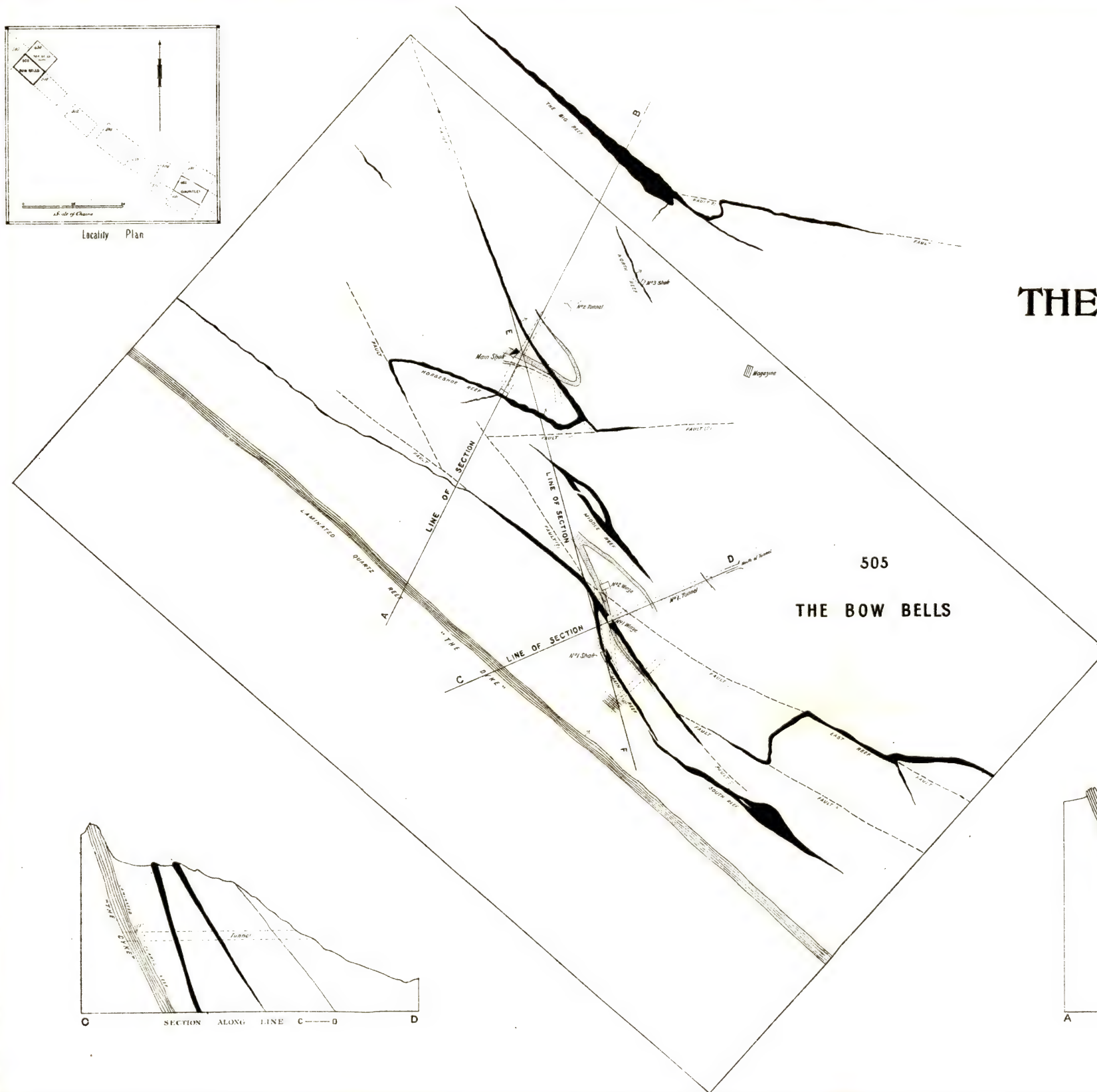
THE HON R. HASTIE, M.L.A.  
Minister for Mines.

# PLAN & SECTIONS OF THE BOW BELLS GOLD MINE

CHAMBERLAIN GROUP, WARRAWOONA.

PILBARA G. F.

BY  
G. Gibb Maitland  
GOVERNMENT GEOLOGIST.



cally, intersects the southern leg of the reef at No. 1 level, put in at a depth of 91 feet 6 inches; this reef is about 3 feet in thickness. The northern leg of the reef is represented by the 12 inches of quartz, intersected in the northern drive at a point about 40 feet from the shaft. An eastern drive about 50 feet in length has been put in practically along the country rock forming the footwall side of the reef. A narrow quartz vein, however, occupied the centre of the drive, and may possibly represent the small vein showing on the surface, for about 30 feet west from the mouth of No. 2 shaft. The eastern drive has been carried south on a bearing of 171 degrees for a distance of 18 feet, through massive greenstone. It is contemplated continuing this with the object of intersecting the rich chute worked in the reef in No. 1 shaft, and hauling all the stone to be milled from the main shaft.

*The Tunnel Workings.*—The workings at No. 1 tunnel and No. 1 shaft, are the most extensive, and appear to be the most important on the property. The mouth of the tunnel is 18·94 feet above the level of the main shaft, and has been carried in for a distance of 85 feet from the mouth to a point at which it intersects the reef, followed down from the surface in the workings from No. 1 shaft. Forty-five feet back from the face of the tunnel is a quartz reef 2 feet 6 inches in thickness, which in all probability represents the northern leg of the main reef. On the surface at the mouth of No. 1 shaft the two legs of the reef are 20 feet apart, whilst in the tunnel, 59 feet vertically below, they are 40 feet apart. Twenty-three feet from the mouth of the tunnel is a small reef of 6 inches underlying to the north-east, and which in all probability represents the feather edge of the middle or lens-shaped mass of quartz (the Middle Reef) shown on the plan (Plate XI.) as lying midway between the Main and the Horseshoe Reefs. From the face of the tunnel, drives have been carried north and south for distances of 60 and 60 feet respectively; and for a length of 40 feet northwards from the face of the tunnel the reef has been stoped out to the surface, and has produced, up to the end of 1903, 483·70 tons of quartz, officially recorded as yielding 855·69 ozs. of gold, or at the rate of 1·76 ozs. per ton. The reef can be followed with more or less interruption northwards, but to the southwards it appears to be represented by a mere thread of quartz. At a point about 60 feet south from the tunnel a crosscut has been put in 40 feet south from the drive, through more or less foliated greenstone, with thin films and threads of quartz along the foliation planes. At the face of the crosscut the laminated quartz vein has been pierced and proved to be 10 feet in thickness, with an underlie of 65 degrees to the north-east. There does not seem to be any distinct line of demarcation between the country rock and the vein; the whole appearance suggesting a gradual replacement of the original rock along lines of maximum compression or foliation. On the footwall side of the vein is a body of quartz of as yet unknown thickness; in its general appearance, this quartz closely resembles some of the auriferous

quartz of other portions of the field, and on that account seems worthy of being, at least, opened out and prospected. From the foot of the main shaft, and at the face of the tunnel, a winze, No. 1, has been carried down on the reef 77 feet 6 inches; this winze, which was inaccessible below 24 feet from the drive, has been put down on the footwall side of the chute followed above. No. 2 winze, however, about 20 feet to the north, has been put down in the centre of the chute, and carried down 83 feet. The chute, which underlies north, leaves the winze at about 40 feet. The reef in this winze is very strong, and in places large, attaining as much as 8 to 10 feet in thickness; at the foot of the winze, owing to a large bulge in the reef, its exact width had not been ascertained at the time of my visit. An intermediate level connects the two winzes at 24 feet 6 inches below the drive; about 200 tons of ore have been taken out above, and now await crushing. The quartz [5782] has a very ice-like appearance, and contains small scales of sericitic (?) mica, and irregular patches of serpentine. A sample of it assayed gold at the rate 1 dwt. per ton. It is contemplated intersecting this chute from No. 1 level in the main (Horseshoe) shaft by a crosscut put in from the face of the eastern drive, as may be seen in the section (Plate XI.). The width of the chute appears to be about 35 or 40 feet.

There are many points of similarity between the geology and economic features of this property and the Gauntlet. The ore deposits in each case belong to one and the same type, and both occur in the same mineral zone.

So far as may be seen by a careful inspection of the surface it appears as though a considerable amount of faulting has gone on. The inferred position of these faults has been indicated upon the plan which forms Plate XI.

The following table gives the yield of the reefs on this property:—

*Table showing the Yield of the Bow Bells Reefs.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1898	.	.	.	.	55·00	152·40	2·77
1899	.	.	.	.	183·00	342·30	1·87
1900	.	.	.	.	104·20	175·29	1·68
1901	.	.	.	.	<i>Nil</i>	<i>Nil</i>	...
1902	.	.	.	.	141·50	185·70	1·31
1903	.	.	.	.	<i>Nil</i>	<i>Nil</i>	...
1904	.	.	.	.	<i>Nil</i>	<i>Nil</i>	...
Total					483·70	855·69	1·76

Adjoining the Bow Bells Lease on the north, and on the ground taken up for a battery site, is another very conspicuous quartz reef.



This bold reef, which outcrops at about 40 feet from the boundary of the Bow Bells Lease, measures about 20 feet in its widest part, and can be followed along the surface for about 484 feet. The eastern end of the reef bifurcates, and both horns of the fork gradually dwindle out to threads of quartz. The western end of the reef is about 50 feet from the north-west angle of G.M.L. 505.

GREAT WESTERN, G.M.L. 502.—An abandoned 12-acre lease lying in the main belt some distance to the south-east of the Bow Bells. Some desultory work has been done upon a well-defined reef, varying from 1 to 5 feet in thickness. The reef occurs in a very much crushed greenstone. The quartz in places contains veins and eyes of banded bright green serpentine [5772] which present every appearance of having been produced by shearing. The reef is in all probability along (or parallel to) the same line of fracture which carries the Main Bow Bells Reef. The quartz is of a white colour, and practically destitute of any other mineral, except a very little pyrites, closely associated with the green serpentine previously referred to. A parallel reef occurs near the south-eastern angle of the lease, but no work has been done upon it.

In 1898, when the property was visited by the then Inspector of Mines, Mr. Gladstone, about 100 tons of quartz had been raised from the first lease, and awaited treatment. No separate crushings from this lease appear in the returns; any returns are in all probability included under the heading of the yield from Sundry Claims.

A tunnel had been put in 55 feet on a bearing of 223 degrees, on the vacant ground lying between this lease and that adjoining G.M.L. 595; the tunnel had been carried through decomposed schist underlying to the north-east. At about 35 feet from the mouth of the tunnel there is about from 6 to 8 inches of quartz exposed, which represents the continuation of the reef opened up in G.M.L. 502; the face of the tunnel exposes a thin vein of quartz from 2 to 3 inches in thickness.

GAUNTLET No. 3 NOR'-WEST, G.M.L. 595 (late Gift).—This abandoned 24-acre lease is traversed by two principal reefs which have been worked at one time or another by three shafts. The most northerly shaft, which is inaccessible, has been sunk to a depth of 15 feet on a reef having a general strike of 107 degrees with a high underlay to the north. A little stone has been taken out from the reef, which, judging from the ore at grass, had a maximum thickness of 12 inches. So far as may be seen in the sides of the shaft the reef is represented by three or four quartz veins about a couple of inches in thickness. The same reef has been opened up at intervals along the outcrop for a distance of about 100 feet eastwards from the shaft; in one place the reef measures from 2 to 3 feet across. A very little stone has been raised and is now stacked; the quartz is of a pure white colour,

and contains small quantities of iron ore; a sample [5774] of it assayed gold at the rate of 1 dwt. 15 grs. per ton.

The principal workings on the lease, however, are on the vein lying to the south-west of the laminated quartz vein and about 148 feet from it. Two shafts, 94 feet apart, have been put down upon the vein. The south-eastern shaft (No. 2) is inaccessible, and no information is available; the vein has been opened up along the surface for a distance of 38 feet along the outcrop south-east from this shaft, but owing to the condition of the workings little is to be seen of it. No. 1, or the westernmost shaft, is distant 94 feet from No. 2, and the stone has been worked right to the surface between the two, but from what depth cannot be ascertained. This shaft, the depth of which is unknown, has water standing in it to about 35 feet from the surface, and is now used as a well. Owing to the influx of water, it is asserted, the property had to be abandoned.

Fig. 42 gives a section across the reef, which lies along a line of fault, the hanging wall of which is marked by a somewhat puckered and greatly slickensided vein of quartz.

This vein is the continuation of Kopcke's Leader.

The following table gives the yield of this reef so far as can be ascertained from official data:—

*Table showing the Yield of the Gift Reef.*

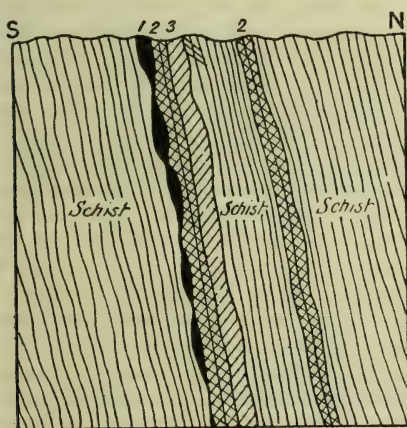
Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	11·80	23·50	1·99
1899 . . . . .	32·25	50·00	1·55
Total . . . . .	44·05	73·50	1·63

GOLDEN GAUNTLET, G.M.L. 506.—This lease adjoins the Gift, on the east; a fair amount of work has been done at the north-west end of the property, on a reef which occurs, as may be seen by an inspection of the geological map, in close proximity to where the main laminated quartz vein is traversed by the green-stone dyke [5773].

A tunnel has been put into the face of the hill on a bearing of 240 degrees, for a distance of about 75 feet. At 34 feet from the mouth of the tunnel, the laminated quartz vein has been met with, and passed through at 47 feet, giving a thickness of 13 feet; the vein underlays to the north-east at 85 degrees. At the face of the tunnel the decomposed rock is much less foliated than that exposed in the rest of the tunnel, thus indicating a gradual decrease in foliation as one approaches, and receded from the quartz vein. There does not appear to have been much obtained from this tunnel,

which would seem to have been driven for the purpose of exploring the laminated quartz vein at some depth below its outcrop. Two shafts, now inaccessible, have been put down on a large reef situated a little distance to the north of the tunnel which has an average strike of 146 degrees. The most northerly shaft, 35 feet deep, is distant 95 feet from the southernmost ; from the foot of the

FIG. 42.



SECTION ACROSS THE GIFT REEF G.M.L. 595.  
WARRAWOONA PILBARA G.F.  
*1 Gift Reef along line of fault 2 White Quartz 3 Black Quartz*

northern shaft a drive has been put in along the reef in both directions, but no particulars are obtainable. The thickness of the reef as measured on the outcrop, close to the northern shaft, is 20 feet, and probably merely represents the widest portion of a bulge in the reef. The quartz is of a bluish white colour, and appears to contain no accessory minerals. A fair quantity of outcrop stone has been stacked and awaits crushing.

*Table showing the Yield of the Golden Gauntlet Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1899 . . . . .	Tons. 3·00	Ozs. 4·60	Ozs. 1·53

GAUNTLET, G.M.L. 483.—The Gauntlet Lease was originally taken up in the year 1898, by Mr. R. H. Mackenzie ; it comprises an area of 12 acres, and has been responsible for a yield of 3693 ozs.



of gold, or 2·86 ozs. for every ton of ore milled up to the close of 1903.

The surface of the lease is occupied by greenstone schists and allied rocks, whilst skirting the southern boundary is a continuous and conspicuous band of laminated quartz about 10 feet in thickness. The foliated greenstone contains large crystals of iron ore, identical with those weathering out of the massive variety.

There are practically four principal reefs, *i.e.* reefs upon which any work has been done, on the ground, the longest having a length along the outcrop of at least 400 feet, and the shortest about 100 feet (Plate XII.). When the position of the reefs is accurately laid down upon a plan, it is noticed that they exhibit, with minor variations, a rude parallelism, the general strike being north-west and south-east, which coincides with that of the foliation and dominant structural features of the district. About 45 feet north of the band of laminated quartz is a fairly continuous quartz reef outcropping for about 500 feet from the north-western boundary of the property. This reef attains a thickness of about 2 feet in places; though as a rule very thin, it is perhaps the one which exhibits the greatest linear persistence on the lease.

*The South Reef.*—The South Reef, which has been opened up by means of a tunnel and several small open-works, can be traced across the surface for about 140 feet. The tunnel has been driven about 31 feet in a southerly direction; at its mouth the reef, merely an exceptionally large lenticular mass of quartz, the maximum thickness of which measures 2 feet 3 inches, has been exposed. The country rock in the tunnel is decomposed schist, with small lenticular “eyes” of quartz developed along shear planes. The open-works on this line merely expose a similar succession of quartz lenticules. In view of the fact that their mode of occurrence is identical with those on that important line, Kopcke’s Leader (*q.v.*), and that they are said to be appreciably auriferous, this line would seem to merit a certain amount of judicious prospecting.

*The Main Reef.*—As developed to the south of the main shaft, from which it is distant 40 feet, the main reef has a continuous outcrop of 132 feet; the eastern end of the outcrop originates as a mere thread of quartz, which gradually increases in size until it reaches a maximum thickness of 10 feet. At the western extremity, where it is truncated by a fault, to which reference will be made later, the reef is about 6 feet in thickness. As shown in the large open cut at the surface, the main reef is intersected by two faults, making an angle of about 55 degrees. What may be called the main or cross fault has a general strike of 163 degrees, and the strike fault, 110 degrees. Fig. 43 shows what may be called the “compound” nature of the reef as exposed in the open cut, the tunnel, and the lowest portion of the workings at the present time. There is a total thickness of about 16 feet of quartz exposed in the open cut, 14 feet in the tunnel, and about 12 feet at the bottom workings. The main reef has been opened up by means of

THE GAUNTLET

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# PLAN & SECTION OF THE GAUNTLET GOLD MINE

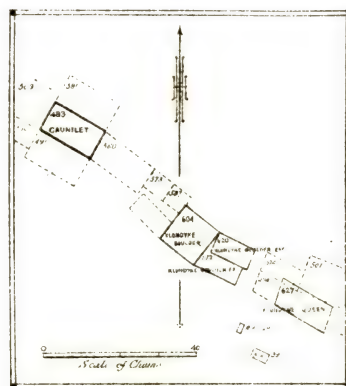
BADEN POWELL GROUP, WARRAWOONA.

PILBARA G. F.

BY  
**G. Gibb Maitland**  
GOVERNMENT GEOLOGIST.

Scale of Feet: 0 100 200 300

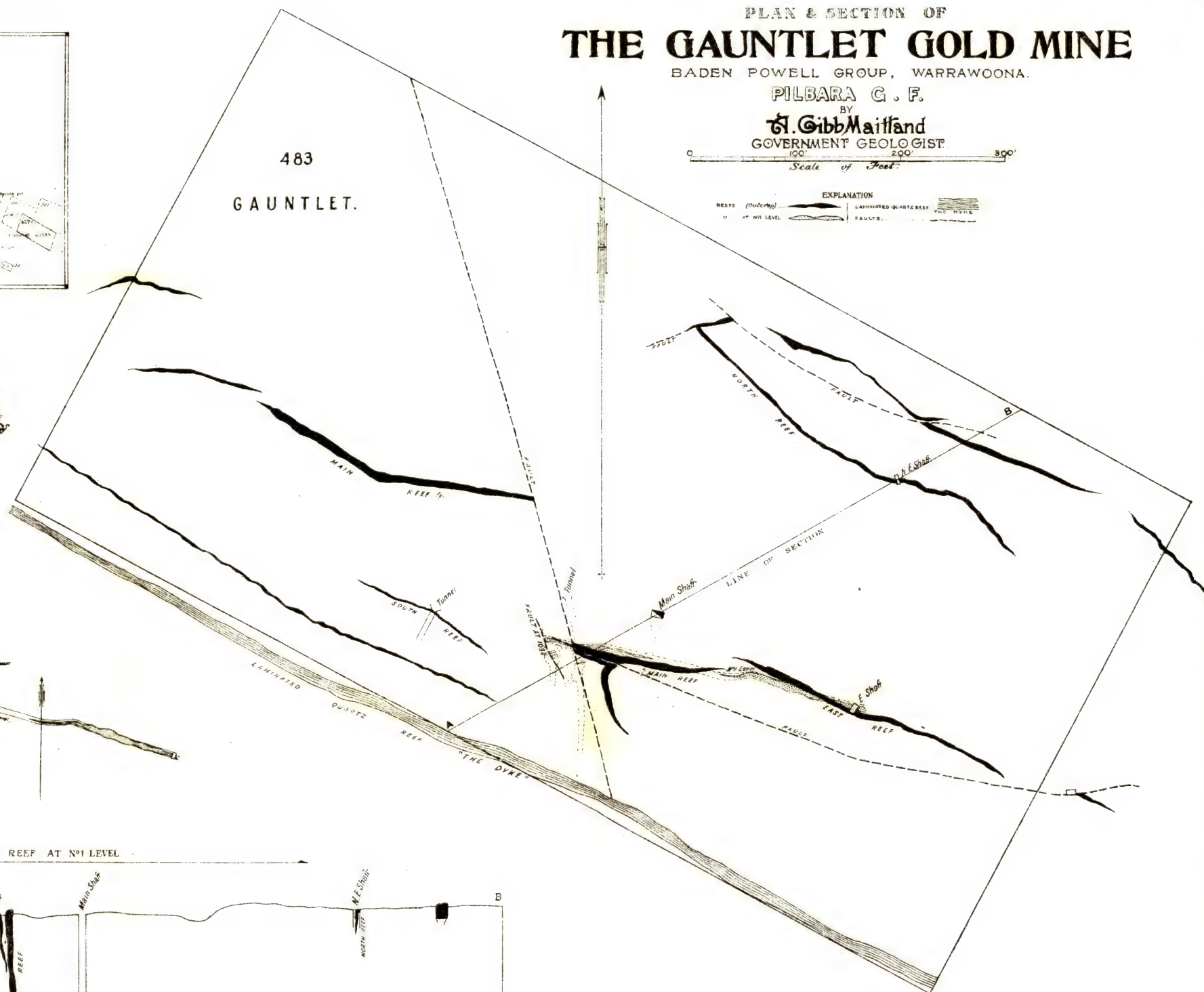
EXPLANATION  
 REEF (outcrop) ——— LAMINATED QUARTZ REEF  
 AT N<sup>o</sup> LEVEL ——— FAULTS ——— V.L. DYKE



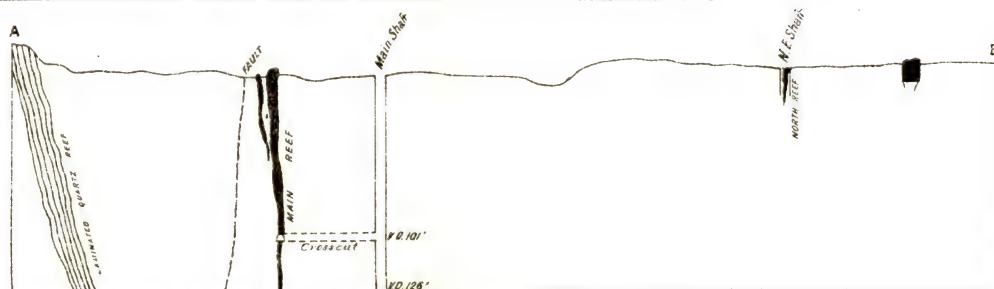
Locality Plan



THE HON. R. HASTIE M.L.A.  
Minister for Mines.



PLAN OF MAIN REEF AT N<sup>o</sup>1 LEVEL



SECTION ALONG LINE A—B

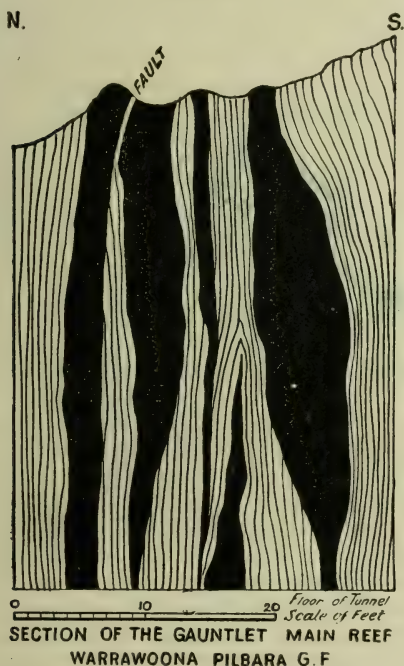
S. H. Smith del.



a vertical shaft (the main shaft) 126 feet 6 inches in depth and a tunnel 168 feet in length. The shaft, which is 8 feet by 4 feet, intersected the reef at 101 feet from the surface, and had been carried down through a foliated green rock. East and west drives, 95 and 201 feet respectively, have been put in at 101 feet; at 116 feet in the shaft is water level, of which there is 10 feet standing.

The tunnel has been put in at a point 85 feet west of the main shaft, about 20 feet vertically below it, and intersects the bottom of the open cut previously alluded to. At about 32 feet from the

FIG. 43.



mouth of the tunnel a winze has been carried down along the plane of the fault to the western end of the drive from the main shaft 87 feet vertically below the level of the floor of the tunnel. Fig. 43 is a section of the reefs, &c., seen in the tunnel at the foot of the open-cut. From this point the tunnel has been carried through foliated country rock, with quartz leaders; on nearing the face of the tunnel the schist becomes much more siliceous, suggesting the proximity of the laminated quartz vein which occupies the surface of the southern boundary of the lease. The whole of the stone has been taken out from the floor of the tunnel to the surface, 38 feet vertically above it, and from this spot practically the whole of the

3693 ozs. of gold, as shown in the return appended, was obtained. From what can be seen in this portion of the mine, it appears that the ore chute lies in, or in close proximity to, the acute angle formed by the two principal faults alluded to previously; the positions of these are delineated on the plan of the reefs and underground workings (Plate XII.).

The main reef has been met with in the west level, opened out from the end of the crosscut, 38 feet in length, south from the main shaft. The reef first makes its appearance as a mere thread of quartz at a point in the drive 23 feet east from the centre of the crosscut; at this spot it measures from 6 to 8 inches in thickness, and gradually increases towards the face. At one point in the drive the reef measures fully 8 feet of solid quartz; powerfully slickensided faces on the foot-wall demonstrate that the reef occurs along a line of fault. The slickensides hade in the same direction as the underlay of the reef, to the northwards. The end of this level intersects the winze from the tunnel overhead, and has been carried down 16 feet 6 inches from the floor of the drive. At the mouth of the winze the main reef measures 3 feet 9 inches; whilst at its foot it is 4 feet 8 inches, with a thin band of schist. Thirteen feet from the north face is a second reef of 24 inches, separated from a third of 3 feet by 10 inches of schist. This section agrees in the main with that occurring in the tunnel at the foot of the open cut, in that there are three bodies of quartz separated by varying thicknesses of schist. The main fault leaves the south drive at a point 26 feet from the foot of the winze on the eastern wall, and does not appear to have been followed. The drive is continued about 22 feet from this point on the western wall of the fault through schist containing thin ribbons of quartz and small cubical crystals of pyrites. An important feature in this winze is an almost horizontal fault, or thrust plane, hading to the north at about 5 degrees, with a horizontal displacement of from 12 to 18 inches to the rise. The fault fissure measures less than 6 inches filled with quartz, which may merely represent a flat leader of secondary origin. The floor of the drive, as ascertained by a trench put in across the mullock with which it had been filled, showed that the reef occurred below the horizontal fault. Free gold is showing freely in the solid stone [5785]. The bottom of the winze is at water level.

The main fault traverses the whole breadth of the lease, and abruptly truncates a bold reef lying some distance north of the north-eastern boundary of the property. There seems to be good reason to regard the reef lying to the west of the fault, and about 120 feet from the mouth of the tunnel, as being the western extension of the main reef. This reef lies near the centre of the lease, and makes a bold outcrop of nearly 300 feet in length; it is, in places, of considerable thickness, and the general mineralogical character of the quartz agrees very closely with that which forms the main reef itself. This possible extension of the main reef, more especially

where it is truncated by the fault, has not been prospected. I understand appreciable quantities of gold have been obtained there. There are two other smaller reefs, shown on the plan (Plate XII.), in close proximity to this one; these also have not been prospected.

*The East Reef.*—The East Reef, as showing on the surface, has an outcrop of 275 feet in length, and a width of about 8 feet in its widest part; both ends of the outcrop are represented by thin threads of quartz. The reef has been opened up both from the main shaft and the east shaft, which is 95 feet in vertical depth, and has been sunk on the reef the whole way. The reef makes its appearance in the eastern drive from the main shaft at a point

FIG. 44.



SECTION OF A REVERSE FAULT IN THE GAUNTLET EAST REEF AT N<sup>o</sup> 1 LEVEL. WARRAWOONA PILBARA G.F.

about 50 or 60 feet from the eastern shaft, where it is represented by a thread of quartz, which gradually increases in thickness until it occupies the full width of the roof of the drive, and attains a maximum thickness of 8 feet. There is at this level a blank space of about 50 feet between the end of the main and the east reef, though at the surface the extent of dead ground is not so great. At the surface the two extremities of the reef are about 14 feet apart in a direction at right angles to the underlay, and, underground, at 100 feet vertically below, the distance is barely 10 feet. Beyond the stone taken out of this reef in sinking the shaft, driving the level, and a little from the small open cut on the surface, no further work has been done. The foot of the eastern shaft also exposes a reverse fault, Fig. 44, which has a throw of about 2 feet, and a hade of 35 degrees to



north 75 degrees east. The quartz exposed in the shaft averages about 3 feet in thickness.

*The North Reef.*—The North Reef lies on the opposite side of the valley which traverses the central portion of the Gauntlet Lease longitudinally, at a considerable elevation above the lowest portion of the ground. The reef outcrops at an average distance of about 90 feet from the north-eastern boundary of the lease, and occupies the surface for a distance of about 440 feet. The north-western end of the outcrop of the reef bifurcates, with an extension of the reef to the north-east of about 40 feet. At this point the stone, which is about 4 feet thick, is abruptly truncated by a fault which also cuts off a larger reef, 160 feet in length, at a point about 200 feet to the south-east. This latter reef makes a very pronounced outcrop, and is of considerable thickness. A vertical shaft, 29 feet deep, has been sunk at a point near the thickest portion of the north reef, but beyond this no other work has been done upon it.

The following table gives the yield of this lease, the gold having been entirely derived from the stone occurring at the faulted extremity of the main reef:—

*Table showing the Yield of the Gauntlet Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	106·20	430·90	4·05
1899 . . . . .	150·10	736·15	4·90
1900 . . . . .	872·00	2,269·00	2·60
1901 . . . . .	136·50	238·05	1·74
1902 . . . . .	24·50	19·45	·79
1903 . . . . .	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>
Total . . . . .	1,289·30	3,693·55	2·86

RANGATIRA, G.M.L. 491.—An abandoned lease, adjoining the Gauntlet, on the south. The property is traversed by two reefs, upon which a little desultory work has been done. A small crushing, particulars of which are given below, has been obtained from this lease.

*Table showing the Yield of the Rangatira Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1899 . . . . .	8·50	5·15	·60

GAUNTLET EAST, G.M.L. 590.—The north-western boundary of this lease is traversed by what may be the faulted extension of the

East Reef of the Gauntlet. An inaccessible vertical shaft has been sunk upon it, but nothing can be seen of the reef and its behaviour underground. To the eastward and not far to the west of the Treble Event boundary, a tunnel 55 feet in length has been driven on a bearing of 296 degrees, through a fine-grained quartz schist [5789] traversed by a deposit of the leader type. Nothing, however, beyond this has been done on the property.

There do not appear to have been any crushings recorded from this lease, unless such are included in the yield of those from Sundry Claims.

IMPERIALIST, G.M.L. 564.—The Imperialist reef lies about 400 feet to the south of what may be called the main reef series of Warrawoona. The reef can be followed more or less interruptedly along the surface for a distance of at least 2200 feet south-east, and as may be seen by an inspection of the geological sketch map (Plate X.), there seems to be good reason to believe that it may extend much farther than this.

The Imperialist has been exploited by three principal shafts, all of which are situated near the western extremity of the outcrop. No work was being carried out at the date the property was visited and the main shaft had been dismantled.

The westernmost shaft (now filled in) is situated near the western extremity of the outcrop of the reef, which at this point strikes 101 degrees. Judging by the condition of the dump and the workings a fair amount of work must have been done from this shaft. Between this point and the Central shaft, 114 feet distant, the reef has been opened out at one or two places, and about 12 inches of quartz exposed. A considerable amount of work has obviously been done from the Central shaft; this shaft, which exposes from 6 to 12 inches of quartz, is inaccessible. The main shaft bears 97 degrees from the Central, and is 83 feet distant from it. Water stands in the shaft at 80 feet from the surface. The quartz lying at the mouth of the shaft contains fragments of serpentine [5775]—a sample of this quartz yielded, on assay in the Survey laboratory, gold at the rate of 1 dwt. 15 grs. per ton—and large veins of calcite [5776], some of which are 12 inches in thickness. The calcite yielded a minute trace of gold per ton. The country rock of the reef is [5777] a talc-chlorite schist. The quartz of the Imperialist, so far as may be judged by the stone in the dump, seems to be a replacement of the country rock.

Near the north-east angle of the lease is another parallel reef of from 6 to 8 inches in thickness, upon which a fair amount of work has been done. The reef has been stoped out to the surface from a depth of 20 or 30 feet; the workings, however, are inaccessible. The country rock is schist of the prevailing type. The quartz is traversed by a small vein of calcite. There are three other more or less parallel reefs in the vicinity of the Imperialist, but no work appears to have been done upon any of them.

The following table gives the yield of the Imperialist reef :—

*Table showing the Yield of the Imperialist Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1899 . . . . .	163·75	214·01	1·30
1900 . . . . .	367·50	389·20	1·05
1901 . . . . .	17·50	26·30	1·50
1902 . . . . .	<i>Nil</i>	<i>Nil</i>	...
1903 . . . . .	147·00	181·07	1·23
Total . . . . .	695·75	810·58	1·16

TREBLE EVENT, G.M.L. 573.—This 6-acre lease adjoins the Dodger on the west. Two apparently deep shafts have been put down upon what appears to be the north-western extension of the Dodger Reef. Nothing, however, can be seen of the reef at the present time. A small trial crushing, of a little over three tons, has been recorded from this reef in 1902, with the results as shown in the table below :—

*Table showing the Yield of the Treble Event Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1902 . . . . .	3·25	4·00	1·23

DODGER, G.M.L. 587.—Two shafts have been sunk on a reef, which lies a short distance to the north of the laminated quartz vein, and parallel to it, but at the present time nothing can be seen of the nature of the reef and its behaviour underground.

KLONDYKE BOULDER BLOCK, G.M.L. 577.—No work has apparently been done upon this property, which was evidently taken up with the object of intersecting the Klondyke Boulder Group of reefs at depth on the underlie.

PRINCESS OF ALASKA, G.M.L. 489.—This is an old abandoned lease, which included within its boundaries the three leases 573,

*Table showing the Yield of the Princess of Alaska Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	11·00	33·56	3·05
1899 . . . . .	29·00	37·05	1·27
Total . . . . .	40·00	70·61	1·76





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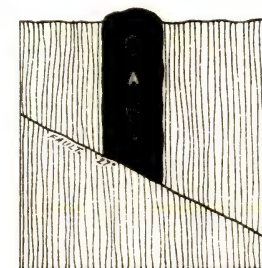
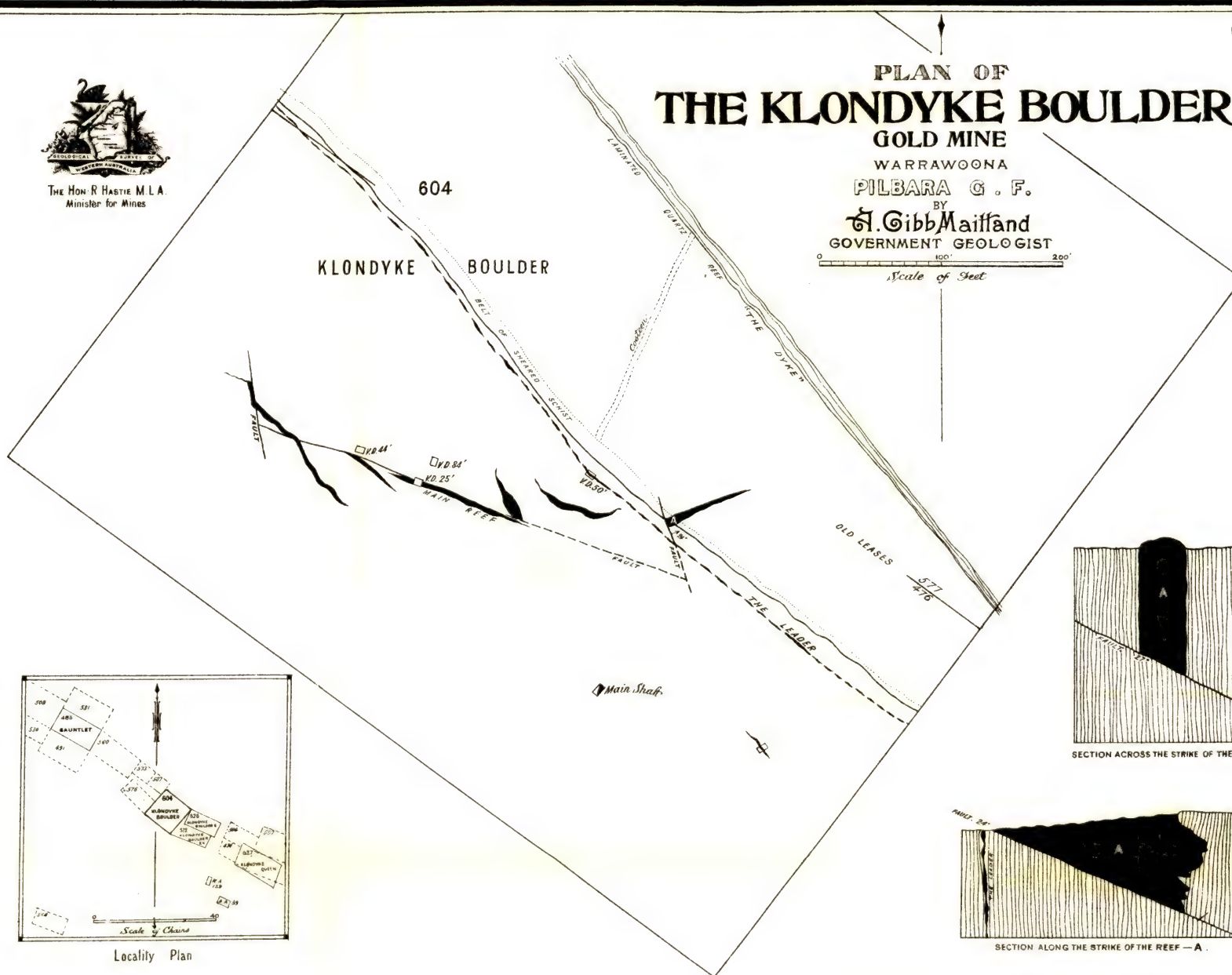
# PLAN OF THE KLONDYKE BOULDER GOLD MINE

WARRAWOONA  
PILBARA G. F.

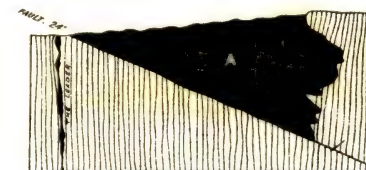
BY  
**H. Gibb Mailland**  
GOVERNMENT GEOLOGIST

0 100' 200'  
Scale of Feet

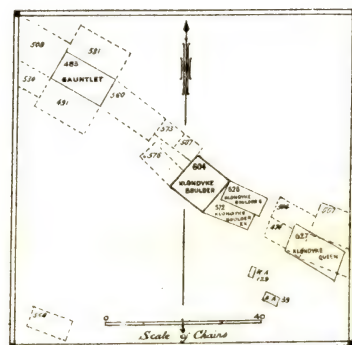
604  
KLONDYKE BOULDER



SECTION ACROSS THE STRIKE OF THE REEF - A



SECTION ALONG THE STRIKE OF THE REEF - A



Locality Plan

5/11/1911



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587, and 577. Two small crushings have been recorded from this in 1898 and 1899, but there is, however, nothing to indicate at the present time whether the stone was obtained from the Treble Event, G.M.L. 573 (*q.v.*) or the Dodger, G.M.L. 587 (*q.v.*).

KLONDYKE BOULDER, G.M.L. 604 (late 476).—This 12-acre lease, which has turned out 2356 ozs. of gold, or at the rate of 2·40 ozs. per ton of ore milled, was originally granted to Messrs. Hall and Cook in the year 1898, and was numbered 476. The lease was subsequently re-numbered 604 on its being conditionally surrendered in 1901.

A considerable amount of work has been done upon the property since it was first exploited, but at the date the locality was visited, the lease being under exemption and the main working full of water, access underground could not be obtained; there appear to be no plans of the workings, hence no information as to the nature and behaviour of the reef below surface is available.

As may be seen by an inspection of the geological map (Plate X.), it will be noticed that the surface of the lease is occupied by greenstone schist; the north-eastern portion of the ground is traversed by a narrow but persistent band of very much sheared greenstone, which forms a very pronounced feature on the surface. This band lies about an average distance of 100 feet south of the conspicuous laminated quartz vein which traverses the field.

All the reefs lie to the south of the laminated quartz vein; they, however, do not occur in that zone which embraces the Bow Bells and the Gauntlet reefs. The Klondyke Boulder reefs present many features in common with those of the two properties mentioned above. The position of the reefs, &c., is shown on the plan which forms Plate XIII.

There are two distinct types of ore deposits on the property, the most persistent being that which may be conveniently termed the leader, which trends generally north-west and south-east, and has an outcrop of not less than 650 feet; the second type being that of the main reef, which has a much more westerly trend than that of the leader.

*The Leader* has been opened up at six or seven places on the lease, but in only one spot (E) does any very serious attempt appear to have been made to exploit it. At this spot a vertical shaft had been put down on a shear plane underlying at a very high angle to the south-west. The shaft proved to be inaccessible; but from what could be seen on the south-eastern wall the reef consisted of eye-shaped masses of quartz encased in slickensided faces of older quartz, about 3 to 4 inches in thickness. There is every geological reason for believing that this reef is merely the north-western extension of Kopcke's leader (*q.v.*).

*The Main Reef* consists of a vein of quartz, having an outcrop measuring about 130 feet in length; it has been worked by means of two shafts, B and C. Shaft B measures 25 feet in depth, and from it is an open cut 83 feet in length, in which a somewhat



tortuous quartz reef is exposed; little, however, is to be seen of it at the present time, though in one place there is about 12 inches of quartz exposed. At the south-west end of the open cut, and about 3 feet from the main reef and on the north side of it, is a large lenticular mass of bluish-white quartz several feet in thickness. Its position is shown on the plan of the reefs forming Plate XIII. There seem good reasons for believing the main reef and this lenticular mass of quartz to be separated by a fault hading to the north. Between this lens and shaft E is another boomerang (kylie) shaped mass of quartz about 80 feet in length. Shaft C, 21 feet northwards from B, is also inaccessible. Water is standing in the shaft; to the top of the water is 84 feet. About 55 feet north-west from the shaft B is another vertical shaft 44 (?) feet deep, sunk with the intention of working the small reef, shown on the plan, outcropping for about 50 feet, and lying a little distance to the south.

To the north-west is a tortuous reef, which occupies the surface for about 140 feet. The reef, which is well seen in the open cut, along its outcrop is traversed by two faults, as shown on the plan (Plate XIII.). The southernmost fault is continuous in a south-easterly direction and probably extends as far as that which truncates the reef outcropping at A, referred to later on.

At A is a quartz reef of 3 feet 10 inches in thickness and 70 feet in length, cut off by an almost north and south fault. This fault, which is exposed in a shallow shaft 9 feet deep, underlies in a direction north 65 degrees east at an angle of 24 degrees. A section is given on Plate XIII. showing this fault; it is, however, taken across the reef and not in the direction of the true dip. There seem good grounds for believing this to be a reverse fault.

The main shaft workings are inaccessible, hence there are no data as to the nature, thickness, and other cognate points of the reef.

The following table shows the yield of this property:—

*Table showing the Yield of the Klondyke Boulder Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1898	.	.	.	.	90.45	379.14	4.19
1899	.	.	.	.	262.45	526.28	2.00
1900	.	.	.	.	253.71	436.55	1.72
1901	.	.	.	.	92.50	287.60	3.10
1902	.	.	.	.	81.05	159.65	1.97
1903	.	.	.	.	198.00	567.00	2.86
1904	.	.	.	.	38.00	94.71	2.49
Total					1,016.16	2,450.93	2.41

WHEEL OF FORTUNE, G.M.L. 611 (formerly G.M.L. 571, and Dawson City, G.M.L. 477).—There are two well-defined reefs on

the property, both of which lie some distance to the north of the conspicuous laminated quartz vein which occupies the southern boundary of the lease. Several shafts have been put down, to depths not known to me, upon that well-defined quartz reef, which lies about 100 feet north of the laminated quartz vein. In August, 1898, Mr. Inspector Gladstone mentions the depths of three of these shafts as being, respectively, 50, 35, and 50 feet, the latter one being on a reef 3 feet in thickness. The reef, as exposed at the surface, is of that bluish-white colour which characterises the reefs of Bow Bells and Gauntlet types.

Some of the quartz [5791] contains quantities of the red oxide and the green carbonate of copper, together with films of sericitic mica and a little serpentine. A sample of the characteristic cupriferous variety [5791] assayed in the Survey laboratory: gold, 4 dwts. 2 grs. per ton, and copper 1·23 per cent. There have been four crushings recorded from this property, details of which are given in the table below:—

*Table showing the Yield of the Wheel of Fortune Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1898	.	.	.	.	25·60	6·90	·27
1899	.	.	.	.	<i>Nil</i>	<i>Nil</i>	...
1900	.	.	.	.	96·50	99·95	1·03
1901	.	.	.	.	16·50	11·50	·70
1902	.	.	.	.	67·75	131·60	1·94
Total					206·35	249·95	1·21

NELSON, G.M.L. 514.—A shallow shaft has been sunk upon a prominent east and west reef, situated near the north-west angle of the property, but very little work appears to have been done upon it. A small trial crushing was obtained from this reef in the year 1898, with the result as shown in the table.

*Table showing the Yield of the Nelson Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1898	.	.	.	.	1·25	5·29	4·23

KLONDYKE NO. 1 WEST, G.M.L. 578 (formerly Klondyke No. 1, G.M.L. 474).—The leader, lying to the south of the laminated quartz vein, traverses the whole length of the property, and all the work done on the lease appears to have been concentrated on it.

Two inaccessible shafts have been put down on the leader, but at the present time there is nothing to be seen of anything underground.

Writing in 1898, Mr. Inspector Gladstone mentioned that the one shaft then sunk had attained a depth of 60 feet, and exposed "a rich leader with three-foot lode formation."

The official returns shown in the table below demonstrate that the leader was rich, crushing nearly at the rate of  $4\frac{1}{2}$  ozs. per ton.

*Table showing the Yield of the Klondyke  
No. 1 West Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	5·00	37·77	7·55
1899 . . . . .	14·95	63·20	4·22
1900 . . . . .	23·05	88·70	3·84
Total . . . . .	43·00	189·67	4·41

KLONDYKE BLOCK, G.M.L. 507.—This 18-acre lease lies north of, and adjoins the Klondyke property. Six well-defined reefs traverse a portion of the property, but no serious work seems to have been done upon any of them. Two of the reefs are of the bluish colour which characterises the quartz of the Bow Bells and Gauntlet reefs.

A crushing of 37 tons has been recorded in the year 1898, the yield of which being shown in the table below:—

*Table showing the Yield of the Klondyke Block Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	37·00	764·00	20·65

KLONDYKE, G.M.L. 473 (now called the Klondyke Queen, G.M.L. 627).—The Klondyke Lease comprises an area of 6 acres, and was originally taken up by Messrs. Poutt and Corboy in the year 1898; it eventually passed into the hands of the present owners, Messrs. Royer and Elliott some time during the year 1903. This lease, as may be seen by the geological map, occupies the same zone as that which embraces the Klondyke Boulder Mine, G.M.L. 604, from which it is distant 28 chains to the south-east. The surface of the property is occupied by the quartzitic rocks, and is traversed by the conspicuous vein of laminated quartz which forms the backbone of the district.



Judging by the condition of the surface a fair amount of work must have been done upon the lease; according to the official records 706·75 tons of ore have been raised, which yielded 4,700·76 ozs. of gold, or at the rate of 6·65 ozs. per ton of stone crushed.

When the property was visited the lease was not being worked, and owing to there apparently being no plans of the workings, very little information as to the nature and behaviour of the deposits is available. The Klondyke reef, as may be seen by the geological map, lies a little distance to the north of the leader.

*The Main Reef* enters the lease on its eastern boundary, where it has been open cut for about 27 feet; there is about a foot of quartz now showing. To a point about 117 feet east of this the reef has hardly been touched, it measures, however, 4 feet across; at this point is the mouth of a tunnel, put in along the reef for a distance of at least 300 feet. Seventy-two feet from the mouth of the tunnel is a winze, inaccessible at the present time, and said to be 90 feet; at this point there is 12 to 14 inches of quartz exposed overhead in the tunnel. The chute of gold followed from the mouth of the tunnel and by the winze is said to be 40 feet wide, with an underlay to the west. The reef has been practically stoped out to the surface to a point from the floor of the tunnel, about 129 feet from its mouth.

A vertical or main shaft connects with a point a few feet to the south of the drive, at a distance of 258 feet from the entrance to the tunnel. Judging from the condition of the workings, the tunnel did not follow the main reef, but merely a thin spur going off to the west.

Free gold is showing in the stone on the outcrop at a point about 50 feet west from the main shaft.

The following table shows the yield of the Klondyke Reef:—

*Table showing the Yield of the Klondyke Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	63·00	836·00	13·27
1899 . . . . .	347·00	1,758·86	5·06
1900 . . . . .	144·50	1,566·20	10·83
1901 . . . . .	86·75	294·40	3·39
1902 . . . . .	65·50	245·30	3·74
1903 . . . . .	<i>Nil</i>	<i>Nil</i>	...
1904 . . . . .	25·00	83·64 <sup>1</sup>	3·34
Total . . . . .	731·75	4,784·40	6·53

<sup>1</sup> Includes 7·33 ozs. obtained by cyaniding 9 tons of sands, the balance being returned from what is now known as the Klondyke Queen, G.M.L. 627.

KLONDYKE, No. 1 EAST, G.M.L. 480.—This 6-acre lease adjoins the Klondyke on the east, and is traversed by the leader, which crosses the whole length of the property.

A tunnel has been put in eastwards from the level of the creek, for an unknown distance, on a reef which bears 287 degrees 30 minutes. Farther east along the outcrop is a vertical shaft 32 feet in depth, designed to connect with the tunnel below. The reef, as exposed on the surface, is about 2 feet in thickness. From its relative position there are good grounds for believing this reef to be the eastern extension of the Klondyke. There do not seem to have been any crushings from this property, unless such are included in returns from Sundry Claims.

BROUGHT TO LIGHT, G.M.L. 516.—This 3-acre lease lies within that zone which includes the Bow Bells and Gauntlet Reefs. There are four well-defined reefs outcropping on the property, but upon one only has any work been done, viz., that near the north-west angle of the adjoining lease number 515. This reef has been opened out along the outcrop for a distance of 50 feet, and in the open cut a vertical shaft 21 feet in depth has been sunk on the reef, which is about 12 inches in thickness. So far as can be seen the reef appears to have petered out at the foot of the shaft.

A small crushing of a little over 8 tons has been recorded from this reef, and its yield is shown in the table below:—

*Table showing the Yield of the Brought to Light Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1899 . . . . .	Tons. 8·75	Ozs. 7·96	Ozs. ·90

THE EARLY MORN, G.M.L. 515.—There are two or three well-defined reefs outcropping on this property, but upon none of them has any work been done.

KLONDYKE No. 2 EAST, G.M.L. 481.—This lease adjoins the G.M.L. 478 on the north-west, and, like it, is traversed along its whole length by the leader. This, which occupies the southern portion of the property, has been opened out in one or two places.

A tunnel, the mouth of which is 35 feet north of the leader, and at a slightly higher level, has been put in, through vertical decomposed schists, for a distance of 84 feet, on a bearing of north 35 degrees east. With the exception of a few irregular quartz leaders, nothing of any importance seems to have been met with. A vertical shaft, designed to intersect this tunnel, was commenced, but after being carried down 10 feet work was abandoned. A second tunnel, 20 feet in length, has been put in at some distance from the longer one, but so far nothing is to be seen. There are

two other reefs lying to the north of the leader, but nothing has been done upon them.

There seems to have been no crushings recorded from this lease, unless any such are included in the returns from Sundry Claims.

ADMIRAL DEWEY, G.M.L. 500.—This 12-acre lease is situated due south of and adjoins G.M.L.s 478 and 481. There are several reefs traversing the property, the most conspicuous and persistent being that which outcrops along the southern boundary of the lease. The outcrop of the reef is interrupted in two places, as may be seen by an inspection of the plan. The country rock of these reefs is greenstone schist of the prevailing type. The only work carried out on this property is near the centre of the northern boundary, where a trench 16 feet long has been put in across the summit of a narrow ridge to a depth of 4 or 5 feet, in which an irregular network of quartz veins and leaders is exposed. The strike of the leaders is parallel to the enclosing schists.

There appears to have been only one crushing recorded from this lease, as shown in the return:—

*Table showing the Yield of the Admiral Dewey Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1898 . . . . .	Tons. 8·45	Ozs. 4·55	Ozs. 53

KLONDYKE KING BLOCKS No. 1, G.M.L. 511.—This lease lies due north of and adjoins G.M.L. 578; it is traversed by two well-defined reefs, which lie within that zone, embracing the Gauntlet and the Bow Bells reefs.

No work of any kind, however, has been done upon these reefs.

KLONDYKE KING, G.M.L. 478.—This 6-acre lease adjoins the Klondyke Queen on the west, and, like it, is traversed by the leader, as well as two other reefs of minor importance on the north. The property, however, has long since been abandoned, though a fair quantity of work has apparently been done upon it.

A tunnel 44 feet in length has been put in on a bearing of 27 degrees through the schists to the leader, which has been connected with the surface by a shaft 31 feet deep. The workings from the tunnel are connected with another shaft 24 feet deep, and situated 48 feet to the west.

The leader, so far as it can be seen, does not present any essential points of difference to that in other portions of the field.

KLONDYKE QUEEN, G.M.L. 488.—The leader traverses the whole length of the lease on the southern flanks of the laminated quartz vein, but the former does not appear to have been opened



out at all. The only work done upon the property is the sinking of a vertical shaft 32 feet deep on a very short east and west reef situated at a point 54 feet north of the laminated quartz vein. An open cut extends south from the vertical shaft and exposes decomposed country rock of the prevailing type.

The only crushing recorded from this lease must have been taken from the east and west reef, previously alluded to. The returns are shown in the table below :—

*Table showing the Yield of the Klondyke Queen Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . .	9.90	13.75	1.38

KLONDYKE QUEEN EXTENDED, G.M.L. 503.—A small 3-acre lease, adjoining the Dead Camel, on the north-west. The property is traversed by the north-western extension of the leader, a fair amount of work having been done along its outcrop, but only to a very shallow depth. There appear to have been no crushings recorded from this property, unless such are included in the returns from Sundry Claims.

To the south of G.M.L. 503 is a faulted inlier of quartzite, in the form of a large attenuated lens, of considerable length but no great breadth. This, however, is too small to be shown on the geological map accompanying the report.

DEAD CAMEL, G.M.L. 475.—The “leader” is continuous through this property, and has been worked for about 100 feet along the outcrop.

A vertical shaft 91 feet in depth has been sunk at one point on the outcrop. Below a depth of 84 feet nothing can be seen of the leader, owing to the shaft being filled in. At the foot of the shaft, so far as can be at present seen, the reef is of the usual lens-shaped type; the lenses being up to 8 inches in thickness, and up to 18 inches in depth.

The returns from this reef are shown in the table below :—

*Table showing the Yield of the Dead Camel Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . .	2.50	9.10	3.64
1899 . . . .	16.25	54.40	3.34
Total . .	18.75	63.50	3.38

Free gold is showing in the stone, in addition to pyrites and galena [5786] and serpentine.

In addition to the leader there are two other quartz reefs on the property situated on the north side of the laminated quartz vein, but no work has been done upon them.

SAINT GEORGE No. 1 WEST, G.M.L. 498.—The reef outcropping in the Saint George traverses the eastern portion of this lease, but little is to be seen. Mr. Inspector Gladstone reports that “an open cut has been worked on the reef. Two shafts have been started and are down<sup>1</sup> about 10 feet. The reef here is 2 feet 6 inches thick.”

SAINT GEORGE, G.M.L. 493.—The 12-acre lease, the Saint George, lies some distance to the north of the leader, and has evidently been abandoned for some considerable time. There has evidently been a good deal of work done on the reef at one time or another. Little or nothing, however, can be seen at the present time. Mr. Inspector Gladstone's report, previously alluded to, makes reference to this property in the following terms: “This is one of the best of the eastern leases on the line. One shaft is down 45 feet, with an open cut about 20 feet. The reef varies from 10 to 15 inches and is very rich in gold. The first crushing gave 110 ozs. of gold from 11 tons of quartz.” The quartz as showing in the face of the open cut near the shaft is pure white and about 1 foot in thickness.

The following table gives the yield of this reef:—

*Table showing the Yield of the Saint George Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1898 . . . . .	Tons. 20·00	Ozs. 124·00	Ozs. 6·20

SAINT GEORGE No. 1 EAST, G.M.L. 499.—Very little work has been done on the reefs traversing this property. There are about three shallow pot-holes, from which about 3 tons of reputedly rich stone have been unearthed.

LAST CHANCE, G.M.L. 540.—An abandoned lease. A fairly well-marked reef, from 12 to 18 inches in thickness, traverses the lease in a north-westerly and south-easterly direction, but beyond opening out the outcrop very little work appears to have been done upon it. The quartz is bluish-white, and contains a little pyrites.

BAND OF HOPE, G.M.L. 533.—An abandoned 6-acre lease adjoining G.M.L. 540 on the east. The main reef traversing the adjoining property crosses the northern portion of the Band of Hope; there are also two other veins to the south of it on the ground, trending approximately in the same direction, but no serious work of any kind has been done upon them.

<sup>1</sup> August 1898.

CUBAN, G.M.L. 492.—A similar condition of affairs prevails on this property as on the Britannia.

The leader, which traverses the whole length of the lease, has been worked to a shallow depth along practically the whole length of the outcrop. At the present time no work is going on, and there is little or nothing to be seen. Mr. Inspector Gladstone's report of 1898 mentions a vertical shaft 20 feet deep, and alludes to a trench 120 feet in length along the outcrop of the leader.

The following table shows the yield of the leader traversing the lease, as obtained from official sources:—

*Table showing the Yield of the Cuban Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	5·00	17·03	3·41
1899 . . . . .	18·20	74·33	4·08
1900 . . . . .	28·10	124·00	4·41
Total . . . . .	51·30	215·41	4·19

BRITANNIA, G.M.L. 484.—An abandoned 6-acre lease, adjoining the Reward and G.M.L. 522 on the west.

A good deal of work has been done along Kopcke's leader, but little can be seen at the present time. Mr. Inspector Gladstone, writing in 1898, mentions a vertical shaft 27 feet in depth, and a trench 160 feet in length; none of these are accessible at the present time, hence no description can be given.

The following table gives the returns from this lease:—

*Table showing the Yield of the Britannia Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	9·50	19·85	2·09
1899 . . . . .	9·50	8·85	·93
Total . . . . .	19·00	28·70	1·51

KOPCKE'S REWARD BLOCK, G.M.L. 522.—There are four short though well-defined reefs outcropping on this lease, but no work of any kind has been done upon them.

REWARD CLAIM 94.—A good deal of work seems to have been done upon this lease. The leader has been worked for a length of 320 feet along the outcrop. There are two vertical shafts 80 feet apart. The western shaft attains a vertical depth of 50 feet, and



has been put down on the western end of a slope, along the footwall of the vein. At the foot of the shaft is a quartz lenticule about 3 inches in thickness; on the hanging wall side of the vein is about 8 to 12 inches of laminated quartz, passing gradually into the softer decomposed (aluminous) country rock. The eastern shaft has been carried down to a vertical depth of 130 feet, but has been filled up to a depth of 100 feet. The largest of the quartz lenses exposed attains a maximum thickness of 12 inches, and a minimum of a quarter of an inch. The quartz contains a little pyrites, green carbonate of copper, and a little galena, which latter occurs pretty well all along the leader. Free gold is showing in the stone at grass, of which there was about 40 tons awaiting crushing. The charges for crushing (30s.) and cartage (10s.) amount to about £2 per ton.

The following table gives the yield of this lease :—

*Table showing the Yield of Kopcke's Reward Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	31·00	160·59	5·18
1899 . . . . .	67·85	210·06	3·09
1900 . . . . .	36·25	101·75	2·80
1901 . . . . .	46·25	126·60	2·73
1902 . . . . .	49·70	147·26	2·96
1903 . . . . .	71·50	166·25	2·32
1904 . . . . .	49·00	125·38	2·55
Total . . . . .	351·55	1,037·89	2·95

WHENNA-PAI, G.M.L. 532.—A small 3-acre lease traversed by the leader, upon which a little work has been done, but the workings are inaccessible.

DAYLIGHT, G.M.L. 496.—An abandoned 6-acre lease adjoining the Juneau on the west.

A good deal of work has been done at different points along the outcrop of the leader, which traverses the whole length of the property. A tunnel 45 feet in length has been put in eastward, close to the eastern boundary of the lease, and exposes quartz lenticules of the usual type. Mr. Inspector Gladstone, writing in 1898, noted the sinking of a vertical shaft 25 feet deep, but such was not accessible to me.

JUNEAU, G.M.L. 479.—An abandoned 6-acre lease adjoining the Criterion on the west. The only work done is an open cut about 120 feet in length put down to a maximum depth of 15 feet upon the line of lenticular quartz veins, the leader. As exposed in the open cut the width of one of these quartz lenses is 2 inches, and its depth 12 inches. About 100 feet south of the leader is a

large ice-like quartz reef parallel to it, and outcropping for about 100 feet along the surface.

Two small crushings have been recorded from this lease, particulars of which are given in the table below:—

*Table showing the Yield of the Juneau Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	5·75	5·55	·96
1899 . . . . .	8·10	9·78	1·20
Total . . . . .	13·85	15·33	1·10

CRITERION, G.M.L. 508.—This property, now abandoned, lies at the south-eastern extremity of the long line of leases which extend across Warrawoona. A tunnel has been driven for a distance of 74 feet on a bearing of 208 degrees through decomposed schist inclined at a high angle to the north. At the face of the tunnel the main band of laminated quartz has been pierced. About a foot north from this is a quartz vein made up of small lenticules. Near the mouth of the tunnel is a vertical shaft measuring 29 feet in depth, but inaccessible at the present time. In addition to this and the tunnel, there are other workings, but as these are likewise inaccessible, no description can be given.

Near the south-eastern boundary of G.M.L. 508 (? on Lease 527, the Lucknow) is an open cut 60 feet in length, varying from 5 to 10 feet in depth, from which a vertical lenticular shaped quartz reef (or succession of quartz lenticules) has been extracted. This vein is the eastern extension of Kopcke's Leader. This open cut exposes a quartz reef underlying at 30 degrees in a direction of south 30 degrees east; there is a length of about 15 feet 4 inches exposed. At the surface the reef is 12 inches in thickness, and at the bottom of the open cut, where it abuts against the leader, it has dwindled to 4 inches.

*Table showing the Yield of the Criterion Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	8·00	3·30	·41
1899 . . . . .	4·20	4·50	1·07
Total . . . . .	12·20	7·80	·63

LONE HAND, G.M.L. 512.—The most easterly of all the leases embraced within the limits of the geological map. This property

has been abandoned for some considerable time. Operations appear to have been confined to opening up a large and well-defined reef, which traverses the northern boundary of the property. The reef has been opened up in three places, along the outcrop, and where exposed, it varies in thickness from 1 to 2 feet. The quartz [5783] is white, and contains the following minerals, the numbers in parentheses indicating their relative frequency: muscovite (3), limonite (3), malachite (2), pyrites (2), chalcopyrite (1), chalcedony (1), gold (1). In addition carbonate of iron is present in some parts. The reef which underlies to the south has a fairly long outcrop.

**SUNDRY CLAIMS FROM THE DISTRICT GENERALLY.**—In addition to the yield of the reefs described above, there are several others which it is impossible to specify, and the returns from which are given in the table below:—

*Table showing the Yield from Sundry Claims, Warrawoona.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1897 . . . . .	5·00	28·93	5·78
1899 . . . . .	187·60	{ 200·82	1·07
		{ 150·00	...
1900 . . . . .	12·20	32·00	2·66
1901 . . . . .	5·00	5·00	1·00
1902 . . . . .	22·00	35·02	1·55
1903 . . . . .	84·85	{ 332·57	3·91
		{ 2433·30	...
1904 . . . . .	70·45	3138·45	1·96
Total . . . . .	387·60	4773·29	1·99

*Synoptical Table showing the Yield of the Warrawoona Reefs up to the end of 1904.*

Name of Reef.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Admiral Dewey . . . . .	8·45	4·55	·53
Bow Bells . . . . .	483·70	855·69	1·76
Bow Bells Block No. 1 . . . . .	12·00	10·50	·87
Britannia . . . . .	19·00	28·70	1·51
Brought to Light . . . . .	8·75	7·96	·90
Carnoustie . . . . .	45·40	178·11	3·92
Chance . . . . .	4·00	8·35	2·08
Criterion . . . . .	12·20	7·80	·63
Cuban . . . . .	51·30	215·41	4·19
Cutty Sark . . . . .	36·05	59·10	1·64

<sup>1</sup> Alluvial.

<sup>2</sup> Specimens.

<sup>3</sup> Fine gold.

<sup>4</sup> Alluvial and specimens not included in total gold.



*Synoptical Table showing Yield of the Warrawoona Reef (continued).*

Name of Reef.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Dead Camel . . . . .	18·75	63·50	3·38
Gauntlet . . . . .	1,289·30	3,693·55	2·86
Gift . . . . .	44·05	73·50	1·66
Golden Gate . . . . .	59·45	124·50	2·09
Golden Gauntlet . . . . .	3·00	4·60	1·53
Imperialist . . . . .	695·75	810·58	1·16
Juneau . . . . .	13·85	15·33	1·10
Klondyke . . . . .	731·75	4,784·40	6·53
Klondyke Block . . . . .	37·00	764·00	20·65
Klondyke Boulder . . . . .	1,016·16	2,450·93	2·41
Klondyke No. 1 West . . . . .	43·00	189·67	4·41
Klondyke Queen . . . . .	9·90	13·75	1·38
Nelson . . . . .	1·25	5·29	4·23
Princept . . . . .	2·15	5·00	2·32
Princess of Alaska . . . . .	40·00	70·61	1·76
Rangatira . . . . .	8·50	5·15	·60
Reward Claim 94 . . . . .	351·55	1,037·89	2·95
St. George . . . . .	20·00	124·00	6·20
Tom Thumb . . . . .	36·55	164·66	4·50
Treble Event . . . . .	3·25	4·00	1·23
Wheel of Fortune . . . . .	206·35	249·95	1·21
Sundry Claims . . . . .	387·60	{ 773·29 1 50·00 2 433·30	{ 1·99
Cyaniding . . . . .	...	3 6·56	...
Total . . . . .	5,700·01	17,294·18	3·03

## L.—MARBLE BAR

*(With a Geological Sketch Map and Section, Plate XIV.)*

Marble Bar is the official centre of the Pilbara Goldfield, and the headquarters of the Warden, the Acting Inspector of Mines, and other officials. The relative position of the centre may be seen by a reference to the locality map which forms the frontispiece to this report. The locality derives its name from the picturesque "bar" of jasper which crosses the Coongan River, about two and a half miles to the south-west of the township. The district has had a somewhat chequered career, and the feverish activity which at one time prevailed has given place to more prosaic conditions.

The mining centre of Marble Bar forms the westernmost extension of that auriferous zone referred to as the Marble Bar, Warrawoona, Yandicoogina, and Mount Elsie Group.<sup>4</sup>

A geological sketch map, to which is attached a generalised section across the field, designed to illustrate its salient structural features, accompanies this report (Plate XIV.). As was the case in most of the other mining fields of the State, by far the larger portion of the area was practically a blank upon any of the existing

<sup>1</sup> Alluvial.

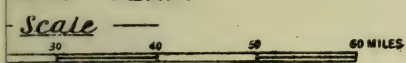
<sup>2</sup> Specimens.

<sup>3</sup> Nine tons of sands.

<sup>4</sup> Bulletin No. 15, p. 33 *et seq.*



# ALITY PLAN.



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HUDSON & KEARNS, LTD, LONDON :





GEOLOGICAL SKETCH MAP

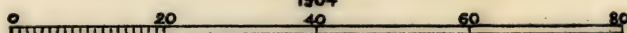
MARBLE BAR

PILBARA G. F.

BY  
G. Gibb Maillard  
GOVERNMENT GEOLOGIST

AND  
H. W. B. Talbot  
FIELD ASSISTANT

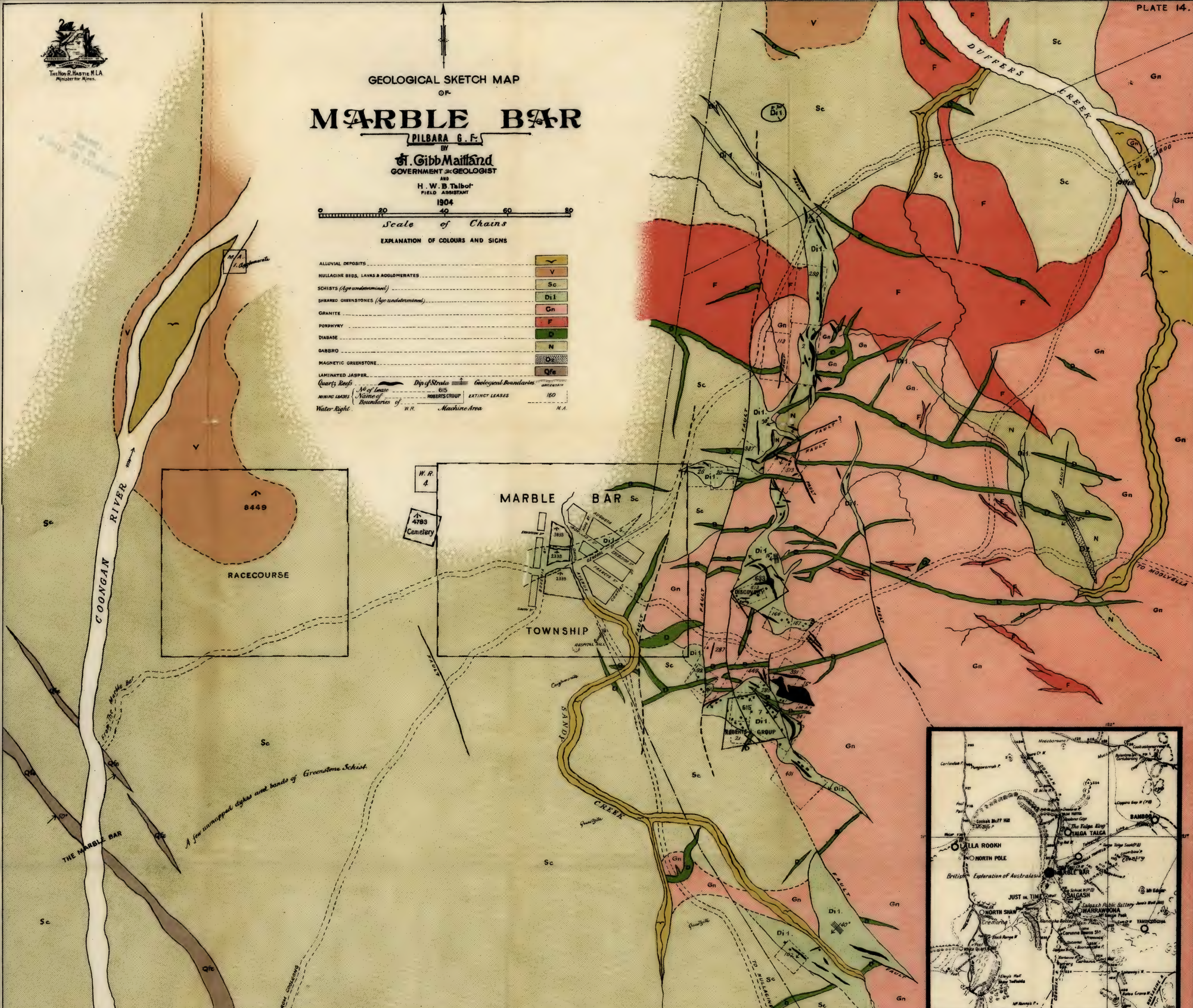
1904



Scale of Chains

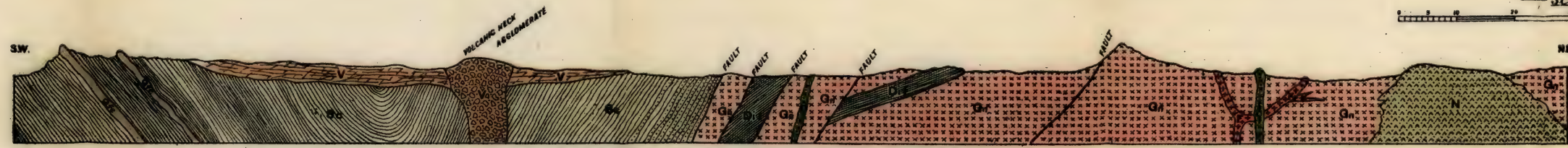
EXPLANATION OF COLOURS AND SIGNS

ALLUVIAL DEPOSITS	V
MULLAGINE BEDS, LAVAS & AGGLOMERATES	Sc
SCHISTS (Age undetermined)	Di 1
SILICIFIED GREENSTONES (Age undetermined)	Gn
GRANITE	F
DIABASE	D
GABBRO	N
MAGNETIC GREENSTONE	Qf
LAMINATED JASPER	Qf
Quartz Reefs	Qf
Dip of Strata	615
Geological Boundaries	160
Water Right	W.R.
Machine Area	M.A.



LOCALITY PLAN.

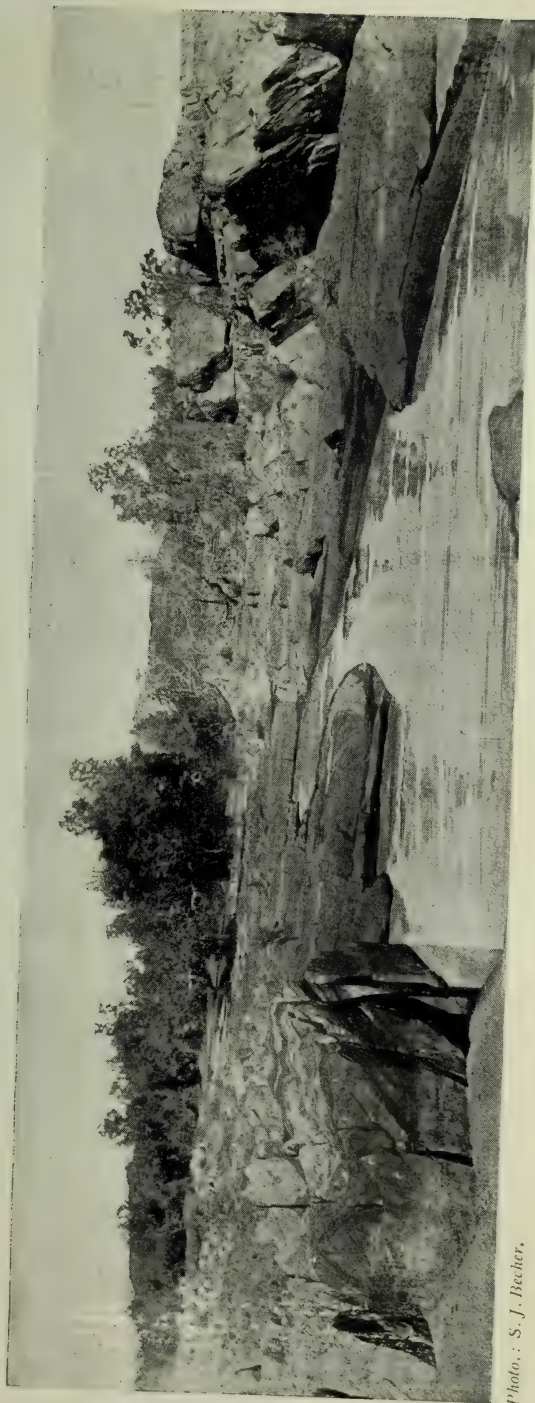
Scale



GENERALISED SKETCH SECTION ACROSS MARBLE BAR.  
LENGTH OF SECTION ABOUT FIVE MILES. NOT DRAWN TO SCALE.



Fig. 45.



Photo, : S. J. Becher,

The Marble Bar, Coongan River,







Fig. 46.



Photo. S. J. Reicher.

Laminated Jaspideous Quartzite, Coongan River, near Marble Bar.

maps, operations had to be commenced by preparing a plan of the more immediate vicinity of the mines.

Marble Bar lies close to what may be called the Main Range, which presents a fairly bold front to the eastward, and the country is drained by the Coongan River and its tributaries—Duffer's and Sandy Creeks.

The Marble Bar centre presents features which link it geologically with Warrawoona and Yandicoogina.

Since the first discovery of the field, about sixteen years ago, Marble Bar<sup>1</sup> has yielded 16,306·74 ozs. of gold, resulting from the milling of 8407·20 tons of ore; these figures give an average of 1·93 ozs. of gold per ton. In addition to these figures there have been officially recorded 2082 ozs. from unknown tons, and 82 ozs. of specimens, thus bringing the total yield up to 18,470·74 ozs.

The various formations represented consist of a series of schists and allied rocks, granites, greenstones, and certain volcanic rocks, which may possibly represent the Nullagine Series as referred to in the earlier pages of the report.

The auriferous reefs of the more immediate vicinity of Marble Bar are embraced within a comparatively narrow belt of greenstone schist, running north and south, and which, as may be seen by an inspection of the geological sketch map (Plate XIV.), has a length of a little over three miles.

The district has been subjected to a considerable amount of faulting, and wherever possible the position and extent of these faults have been laid down upon the map.

## GENERAL GEOLOGY

The different rock masses have as far as possible been mapped, but it has not been found possible to do this in the same detailed way with regard to all the other rocks lying between Marble Bar and the Coongan River.

### Alluvial Deposits

Most of the watercourses in the district are occupied with a more or less width of alluvium, but in no case did these deposits attain any great thickness, nor are they of any economical importance.

### Schists

By far the largest portion of the district embraced by the geological map is made up of schists, both acidic and basic, which bear a very strong resemblance to those occurring at Warrawoona.

Some of the schists in the vicinity of Hospital Hill, and adjoining the road to Nullagine near the crossing of Sandy Creek, are associated with beds which have every appearance of being

<sup>1</sup> *i.e.* the Marble Bar District as defined by the Mines Department.

transmuted quartzites and conglomerate. Much more detailed investigation, however, than was possible at the time I visited the district is necessary before it can be definitely asserted that these acidic schists are of sedimentary origin. So far, however, as can at present be seen, it appears that these schists are arranged in synclinal trough, as shown in the generalised section at the foot of the geological map.

These schists are of economic importance by reason of the fact that they almost invariably form the matrices of the auriferous quartz reefs.

The schists are traversed by two bands of laminated quartz or jasper, the position of which is indicated on the geological map. The most conspicuous, however, is that known as the Marble Bar, which crosses the Coongan River about two and a half miles south-west of the township. A view of this forms the photograph in Fig. 45.

The "Bar" is a long razor-backed ridge (Fig. 46) of laminated quartz or jasper, which rises to a considerable height above the general level of the surrounding country. The width of this band is naturally variable, but in one place near the Coongan River it measures as much as 220 feet from wall to wall. As seen in section, the banded jasper is inclined at an angle of 50 degrees to the north-west. The rocks forming this band can be followed across country for a considerable distance, and form a belt parallel to those similar beds described in Bulletin No. 15. The jaspers [609, 3593, 3695] present a brilliant appearance, due to the inter-lamination of red, white, and dark-coloured bands (Fig. 47) with intermediate varieties, the differences in colour being due to the occurrence of iron in the form of either limonite, hematite, or magnetite. Some portions of the rock contain small but perfect crystals of magnetite.

When carefully examined the banded jasper is found to be much fractured and faulted, Fig. 48 [609], some of the cracks thus formed being filled with secondary silica. The occurrence of these cracks filled with secondary silica is such as to cause the stone to break up into slabs and blocks of an extremely irregular size.

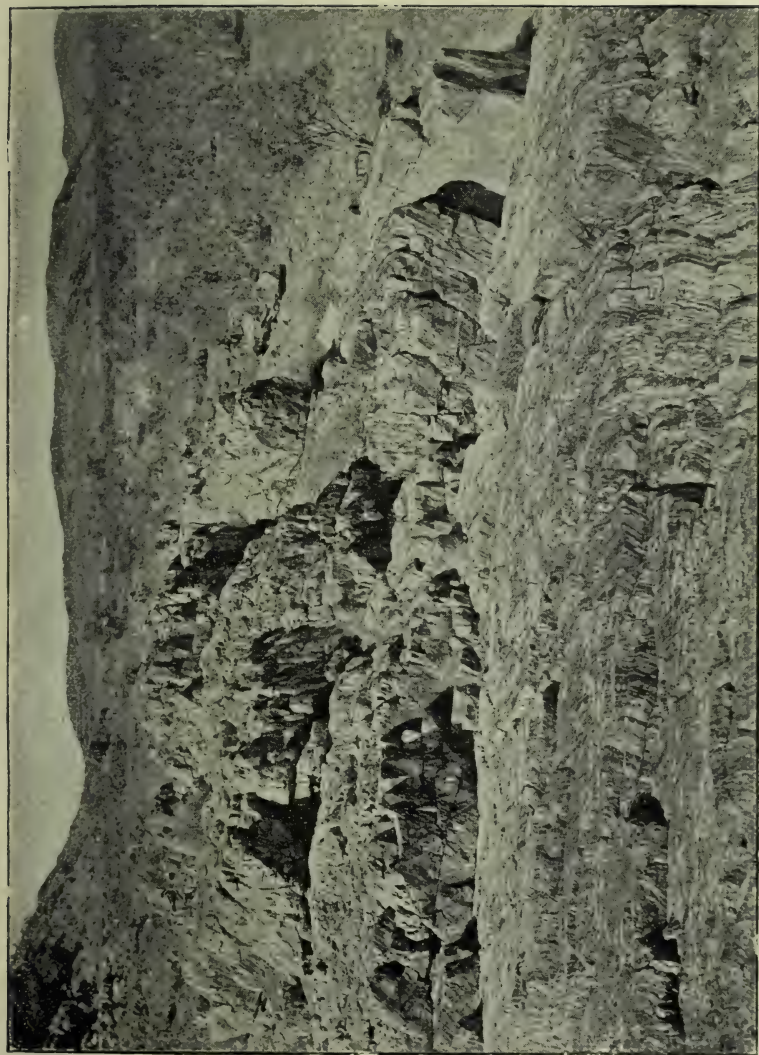
The jasper takes an excellent polish, and those portions of the rock which may be found free from flaws, &c., could doubtless be used for ornamental purposes were its geographical position somewhat more accessible. A typical sample [3695] of this banded jasper which was cut and polished in Europe for use at the Paris and Glasgow Exhibitions is now in the Museum of the Geological Survey.

### Granite

A very large area of country to the east of the township of Marble Bar is occupied by granite. The mass presents in places a very rugged surface, which rises in two conspicuous hills of considerable elevation about due east of the town. The granite



Fig. 47.



*Photo. S. J. Becher.*

Banded Jasper, near The Marble Bar, Coongan River.



presents the same general features throughout its whole extent. In its lithological characters it consists of quartz, felspar, and a little mica. The mass forms one extremity of that granite which embraces the Moolyella Tinfield described in Bulletin No. 15.

### Porphyry

The granite has been invaded by dykes of porphyry [5392, 5812], whilst a very extensive area occurs in the vicinity of Duffer's Creek. In their lithological character these porphyry dykes resemble those of Warrawoona very closely. An analysis of a typical porphyry [5392] is given on page 12 of Bulletin No. 15, also p. 7 above.

FIG. 48.



Faulted Jasper, Marble Bar.

These dykes agree very closely with those porphyries of Warrawoona, described in the earlier pages of this report.

### Gabbro

Adjoining that tributary of Duffer's Creek, close to the eastern boundary of the geological map, is a fairly extensive area of a dark green basic rock [5809] which consists of felspar (saussurite?), a ferro-magnesian constituent, which appears to be hypersthene and its alteration products, a little quartz, and an iron ore. Another similar area occurs a little to the south of the Ironclad Mine, G.M.L. 2.



### Diabase Dykes

A very important feature in the geology of Marble Bar is the number of basic dykes, which an examination of the geological map shows have a general easterly trend. The dykes are all readily distinguished by their dark greenish colour, a rusty and in places exfoliating weathering, and in the majority of cases a tendency to verticality. The dykes have proved in the vicinity of Marble Bar of considerable value in working out the geological structure of the district. An inspection of the map demonstrates that only in one case do they intersect those sheared greenstones which form the auriferous series.

Owing to the marked features which many of these dykes exhibit on the surface, the mapping of them proved a relatively easy task. These basic rocks form part of that system of dykes which make such a marked feature in certain portions of the Pilbara Goldfield, and to which allusion has been made in the earlier pages of this report, and in Bulletin 15.

An examination of the geological map will show that many of these dykes have been faulted, but in no case does the horizontal shifting appear to have been very great. There are no data, however, by which any estimate of the amount of vertical displacement can be arrived at. The hade of the majority of the faults, however, is to the west, as may be seen in one or two sections. The dykes are all of a fine grain.

## ECONOMIC GEOLOGY

### THE MINES

Although practically none of the mines at Marble Bar were open to my inspection, the following information extracted from the field notebooks of the late Mr. S. J. Becher give some idea of the condition of affairs prevailing, and other cognate points at the time this officer visited these properties.

In order to facilitate description the mines are described in geographical order, commencing at the northern end of the leases. The position of the various properties is shown upon the geological sketch map attached (Plate XIV).

WESTERN SHAW No. 1 NORTH, G.M.L. 291.—The most northerly of all the leases embraced within the area of the map, and traversed by four small quartz reefs, which underlie west. No work, however, appears to have been done upon them. The reefs are enclosed in the belt of sheared greenstone, which forms the main auriferous series of the district.

IRONCLAD NORTH, G.M.L. 299.—The lease is traversed by a well-defined quartz reef, which extends along the whole length of the eastern boundary of the property, and underlies to the west.

The developments on the property consisted of two vertical and

one underlay shaft. One shaft had been carried down to a vertical depth of 25 feet, and continued for a short distance on the reef. A drive had been put in to the north from the foot of the vertical shaft to a point 35 feet distant, where the reef pinched out. Another drive had been continued to the south for 74 feet, and the reef is said to have averaged 3 feet in thickness, but only crushed, however, 8 dwts. to the ton.

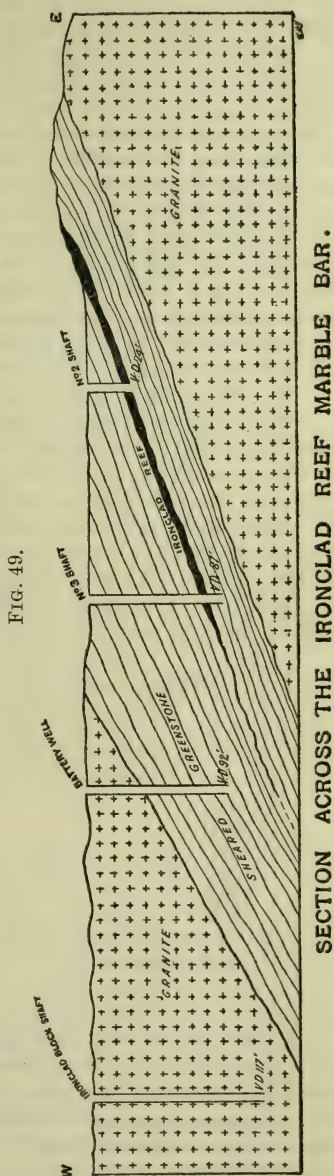
The second vertical shaft was 55 feet in depth, but no particulars appear to be obtainable regarding it. The underlay shaft had been carried down 35 feet.

The yield of this reef may have been included under the heading of Sundry Claims.

IRONCLAD, G.M.L. 2.—The ore deposits on the Ironclad Lease consist of five well-defined reefs, which lie within the belt of greenstone as shown on the map. The surface of the western half of the lease is occupied by granite, beneath which the sheared greenstone passes. At one time a fifteen-head battery was erected on the property. Near the north-west angle of the lease is the well, near the old battery site, which had been carried down to a vertical depth of 92 feet. In this well the granite extends to a depth of 40 feet, at which point it gives place to schist. The water level is said to have been at 75 feet, and the amount of water which the well made was estimated at 600 gallons per hour.

The northernmost shaft on the field is an underlay put down on the reef at a point about 5 chains from the northern boundary, but this is at the present time totally inaccessible.

The principal work on the lease has been carried out upon what may be called the main



Ironclad reef, which outcrops boldly along a low ridge near the eastern boundary of the lease.

The stone which forms the main reef consists of white quartz, with very ferruginous patches.

A tunnel has been driven in from the side of the hill, along the strike of the reef on a bearing of 141 degrees for a distance of 145 feet, thence 14 feet on a bearing of 182 degrees to a point at which the main reef is first intersected. From this point a drive has been carried along the reef for a distance of at least 138 feet. The reef, as exposed at the first bend in the tunnel, measures three feet in thickness. These workings connect with the surface by two vertical shafts, one being 24 feet deep, and the reef stoped right up to the surface. In this portion of the workings the average thickness of the reef is 4 feet. The second vertical shaft, 128 feet west, had been carried down to a depth of 87 feet, and intersected the main reef at 74 feet. A drive is said to have been put in 16 feet south on the reef, which has an average thickness of about 20 inches.

Fig. 49 shows a section across the Ironclad Reef, &c.

Near the south-east angle of the lease are three inaccessible shafts, not indicated on the map; the northernmost of the group being an underlay put down on the reef to a depth of 120 feet. The reef is said to have attained an average thickness of 5 feet. A second underlay, some little distance to the south on the same reef, is said to have been carried down to a depth of 40 feet. West of this is a vertical shaft 34 feet deep.

The following table gives, so far as can be ascertained from official sources, the yield of the Ironclad Reef:—

*Table showing the Yield of the Ironclad Reef.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1893 . . . .	297 00	774·30 <sup>1</sup>	2·60
1894 . . . .	94·00	163·00	1·73
1895 . . . .	1,097·00	258·00	·23
1896 . . . .	531·00	239·02	·45
1898 . . . .	21·50	7·25	·34
Total . . .	2,040·50	1,441·57	·70

IRONCLAD SOUTH, G.M.L. 108.—This is a 24-acre lease, adjoining the Ironclad. There are three small but distinct reefs upon the property, but very little work of any description appears to have been done upon them. An opencut has been put in along the reef, averaging about 12 inches in thickness, which may represent the southern extension of the Ironclad. Three underlay

<sup>1</sup> Of this amount, 418 ozs. has been obtained from a crushing of unknown tons.



shafts, 34, 54, and 20 feet respectively, have been put down, but these are inaccessible. The principal workings are an underlay shaft, 65 feet in depth, from which drives have been put in east and west for distances stated to be 60 and 20 feet respectively. The only separate record of any crushing from this mine is one in 1895 of 61 tons, which yielded 24 ozs. of gold, or at the rate of .39 oz. per ton.

IRONCLAD BLOCK, G.M.L. 113.—The surface of the Ironclad Block Lease is occupied by granite, and a vertical shaft has been put down at a point 7 chains from the south-east angle of the lease, and designed to intersect the main Ironclad Reef at about 200 feet. This shaft had been carried down to a vertical depth of 117 feet through granite. The relative position of this shaft is shown in Fig. 49, *supra*.

IRON DUKE, G.M.L. 387.—This lease embraces part of an area which included the old leases, G.M.Ls. 63 and 8.

A shaft, not shown on the plan, has been put down to a depth of 40 feet, upon an approximately north and south reef, which is stated to have been of very variable thickness, but to have reached as much as 3 feet. The reef which underlays west is of white quartz.

In 1896, 40 tons of quartz raised are stated to have yielded 25.70 ozs., or at the rate of .64 oz. per ton.

KEEP-IT-DARK, G.M.L. 296.—This old lease embraces a portion of the abandoned M.L. 8, The General.

A considerable amount of desultory surface work has been done.

Two vertical shafts, 20 feet in depth, had been sunk upon the eastern extremity of the east and west reef, adjoining the main fault which traverses the property, but these were long ago abandoned. Two other underlay shafts, one of them 12 feet deep, had also been put down, but these were also inaccessible. A crushing of 32.5 tons in 1896 yielded 73.65 ozs. of gold, or at the rate of 2.26 oz. per ton.

The general reef outcrops upon what was originally M.L. 8 (G.M.L. 485), now embraced by G.M.L. 296.

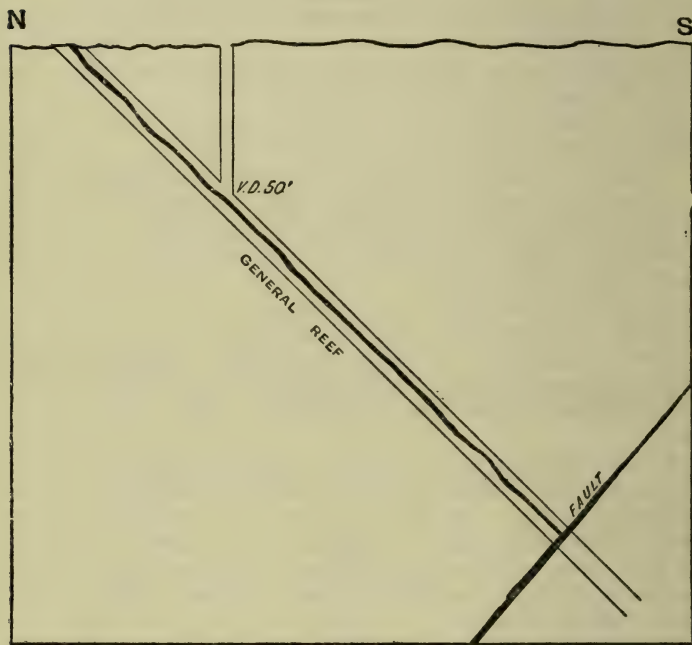
The general reef which outcrops just outside the northern boundary of G.M.L. 296 is a well-defined body of quartz, striking north and south and underlying at an angle of between 40 and 50 degrees to the east. This reef has been extensively worked by the previous holders of the lease. The reef has been followed down from the surface for a distance of over 180 feet. A vertical shaft (Fig. 50) about 50 feet in depth intersected the reef, which was followed down for a further distance of 150 feet. The reef was abruptly cut off by a fault underlying west, but the shaft was continued for a further distance of 30 feet through country rock. A good deal of work appears to have been done underground, but there was very little to be seen at the present time. The fault seen at the bottom of the shaft is also visible in the workings at the

eastern end of No. 1 level; the fault also underlies to the west. There are several faults in the vicinity of the reef, some of which are shown on the geological map (Plate XIV.) so far as the small scale will admit.

HOMeward BOUND, G.M.L. 613.—This lease embraces a portion of the ground embraced by the old Homeward Bound Lease, G.M.L. 579.

There is one fairly large-sized reef cropping out near the

FIG. 50



SECTION ACROSS THE GENERAL REEF MARBLE BAR.

northern portion of the property, and trending generally north and south with an east and west arm. This reef is almost flat.

Upon the old Exhibition, G.M.L. 286, which includes the northern portion of the Homeward Bound, little else than surfacing seems to have been done.

Upon the greater portion of the western half of the Homeward Bound, lie all the old "Rejected" workings. Several shafts have been sunk, and much surface work done by previous owners upon an interrupted line of reef, which has a southerly underlay and a general east and west strike.

The reef is said to lie fairly flat and with an average thickness of about 12 inches, with, however, big bunches here and there.

An underlay shaft had been sunk on the reef to a depth, on 17th September 1896, of 50 feet on a good body of stone.

The Rejected No. 1 Reef (on old G.M.L. 84) does, however, appear to be upon exactly the same line as that just described. The reef outcropping has been worked by a main vertical shaft 40 feet in depth, which, up to the end of September 1896, had been continued on the underlay for a further distance of 81 feet. Two reefs are said to have been exposed in the workings, separated by a horse of country. The lower reef is said to have possessed good, well-defined walls, which had an underlie of about 35 degrees to the south. The upper reef, reputed to have been the most regular of the two, had an average thickness of about 2 feet. Near the foot of the underlay shaft, the reef varied from 18 inches to 5 feet in width.

So far as can be ascertained from the official figures, the yield of the reefs on the present Homeward Bound Lease appears to have been as shown in the following table:—

*Table showing the Yield of the Homeward Bound Reef.*

Year.	Name of Lease.	Ore Crushed.	Gold there- from.	Rate per Ton.	Total Ore Crushed.	Total Gold there- from.	Average Rate per Ton.
		Tons.	Ozs.	Ozs.	Tons.	Ozs.	Ozs.
Previous to 1897	Rejected, G.M.L. 105	1,208·00	1,827·00	1·51	1,273·00	1,894·00	1·48
1897	„ „	65·00	67·00	1·03			
1898	Homeward Bound, G.M.L. 615	249·75	261·15	1·04			
1901	„ „	198·75	242·25	1·22	455·50	526·30	1·15
1902	„ „	7·00	22·90	3·72			
Total . . . . .					1,728·50	2,420·30	1·40

SHAMROCK, G.M.L. 160.—An old 6-acre lease upon which a fair amount of work must have been done at one time or another. Near the north-eastern angle of the lease is an underlay shaft put down to a depth of 100 feet, on the reef outcropping on the crown of the hill. This reef was intersected by a vertical shaft, No. 1, and farther south-west by shaft No. 2, at depths of which there is no precise information. A third shaft had been sunk at a point 35 feet west of No. 1 to a depth of about 30 feet, but no particulars are available beyond the fact that a quartz reef 5 inches in thickness had been met with.

The following is a list of the crushings from this property, so far as are disclosed by the official statistics:—



*Table showing the Yield of the Shamrock Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1895	.	.	.	.	52·25	120·10 <sup>1</sup>	2·29
1896	.	.	.	.	8·00	22·70	2·83
Total					60·25	142·80	2·37

TRUE BLUE, G.M.L. 157.—An old 6-acre lease adjoining the Shamrock on the east. A considerable amount of open cast work has been carried out. The northernmost shaft on the lease is an underlay shaft 90 feet in depth, connecting with a vertical shaft 24 feet in depth, which had been continued for a further distance of 24 feet on the underlay of the reef. The reef averages 2 feet in thickness, and underlays about 30 degrees to the south-west. There is another parallel reef below this one, which attains a thickness of about 2 feet.

The figures in the table below give the result of the crushings, so far as may be gathered from the official records:—

*Table showing the Yield of the True Blue Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1893	.	.	.	.	2	61·20	...
1894	.	.	.	.	35·50	42·00	1·18
1895	.	.	.	.	92·50	168·82	1·82
1896	.	.	.	.	55·25	38·00	·68
Total					183·25	310·02	1·69

MARBLE BAR, G.M.L. 288.—An old 12-acre lease adjoining the Coongan Star Extended on the north, from which in the year 1898, 11 tons of ore yielded 15·70 ozs. of gold, thus giving an average of 1·42 ozs. of gold per ton.

COONGAN STAR, G.M.L. 92.—Upon this 6-acre lease a good deal of *bonâ fide* work has apparently been done in times past upon a north and south reef, inclined at a very low angle to the west, but which makes no very pronounced outcrop on the surface. An old disused main shaft has been put down upon the summit of a low hill, and the reef worked out about 50 or 60 feet on the underlay.

A vertical shaft had been put down to a depth of 20 feet at a point 150 feet from the summit of the hill, but no particulars are obtainable respecting it.

<sup>1</sup> Includes 33 ozs. from unknown tons.

<sup>2</sup> Unknown.

Adjoining this is another 25 feet in depth, from the bottom of which a drive had been put in 40 feet to the south-east, whilst a third shaft near by had been sunk to an unknown depth. In addition to these old workings is a vertical shaft 33 feet in depth, at which point the reef is met with; this has been followed on the underlay for a further distance of 37 feet. About 100 tons of quartz have been raised and awaited crushing.

*Table showing the Yield of the Coongan Star Reef.*

Year.					Ore Crushed.	Gold therefrom.	Rate per Ton.
					Tons.	Ozs.	Ozs.
1894	.	.	.	.	184·50	310·15	1·68
1895	.	.	.	.	75·50	131·80	1·74
1896	.	.	.	.	71·25	157·00	2·20
Total					331·25	598·95	1·80

COONGAN STAR EXTENDED, G.M.L. 287.—Near the south end of the lease, adjoining the south-east angle of the Coongan Star property, a shaft 25 feet deep had been put down upon a small but good quartz vein, from which a small trial crushing is asserted to have yielded an average of about 2 ozs. per ton.

A quartz reef in granite country outcrops near the north-west angle of the lease, but no work appears to have been done upon it. A water shaft of unknown depth is to the west of the reef.

AUGUSTA, G.M.L. 615.—This lease, as at present constituted, embraces by far the larger portion of what was originally included in the Stray Shot, G.M.L. 3, the Excelsior, G.M.L. 21, and the Augusta, G.M.L. 7.

The Augusta reef makes a fairly distinct and well marked outcrop on the surface; the reef, however, has been interrupted near the southern angle of G.M.L. 280, by a north and south fault, which has but a slight throw.

The outcrop of the reef is traceable all round the north-east, east, and south-east sides of the hill, and averages about 3 feet in width, it extends westwards as far as the Stray Shot, where it is worked by several shafts. There seems, however, good reason to believe that the reef in the Surprise Lease, G.M.L. 167, adjoining the Stray Shot on the west, is the continuation of the Augusta, interrupted, however, by a small fault, lying parallel to that alluded to above. Along the eastern outcrop of the main Augusta reef stone has been broken out in several places.

The Augusta Reef has been worked by a main shaft which has been carried down on the underlie of the reef which is very flat for a considerable distance.

At the 75 feet, 150 feet, and the 266 feet levels drives have been put in for varying distances, but in the absence of an adequate

plan of the mine any intelligible description of the reef underground is well nigh impossible, more especially as the majority of the workings are inaccessible.

Overlying the reef is a dyke [5819] of a fine-grained rock, which, under the microscope, seems to consist principally of felspar and an altered dichroic ferro-magnesian constituent.

In the underlay shaft at the 75 feet level the main Augusta Reef is said to have attained a maximum thickness of 7 feet, but in the lower levels of the mine it averages only about 12 inches. It is stated that where the reef is wide the good stone is confined to certain bands, chiefly, however, of highly-mineralised bands; in the lower levels of the mine, where the reef is smaller, most of the stone is said to have been worth crushing.

The main Augusta Reef extends right through the Excelsior and the Stray Shot, below the level of the Stray Shot Reef. A great number of shafts have been sunk at relatively short distances apart on the slope of the hill and a considerable amount of surface work done. The quartz is of a darkish hue, and contains relatively small quantities of the sulphides of iron, copper, and lead.

*Table showing the Yield of the Augusta, Stray Shot, and Excelsior Reefs.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Previous to 1897 . . . .	3,349·00	{ 9,219·00 1 2,082·00 }	2·75
1897 . . . . .	1,661·70	1,818·28	1·09
1898 . . . . .	291·70	363·49	1·24
1899 . . . . .	230·00	322·40	1·40
1900 . . . . .	72·00	{ 30·96 2 195·00 }	·43
1901 . . . . .	15·00	26·60	1·77
Total . . . . .	5,619·40	<sup>3</sup> 11,780·73	2·09

SUNDRY CLAIMS FROM THE DISTRICT GENERALLY.—In addition to the yield of the reefs described above, there are several others which it is impossible to specify and the returns from which are given in the table at top of p. 215.

It is, however, not quite clear from the manner in which the returns are presented whether or not these sundry claims include the yield from reefs in other centres not embraced within the limits of the geological map of Marble Bar.

<sup>1</sup> From unknown tons.

<sup>2</sup> From tailings.

<sup>3</sup> Does not include ounces from unknown tons and from tailings.



*Table showing the Yield from Sundry Claims,  
Marble Bar.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1897 . . . . .	94·50	119·17	1·26
1898 . . . . .	206·00	{ 444·15 1 1,000·00	{ 2·15
1899 . . . . .	104·30	{ 244·62 1 1,770·00	{ 2·34
1900 . . . . .	15·00	14·00	·93
1903 . . . . .	24·00	24·00	1·00
1904 . . . . .	...	2 916·35	...
Total . . .	443·80	3 845·94	1 90

*Synoptical Table showing the Yield of the Reefs of the Marble Bar  
Mining Centre up to the end of 1904.*

Name of Reef.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Augusta . . . . .	5,619·40	14,057·73	2·50
Augusta No. 1 South . .	66·00	149·60	2·26
Coongan Star . . . . .	331·25	598·95	1·80
Excelsior . . . . .	Included under Augusta.		
General . . . . .	Included under Homeward		Bound.
Homeward Bound . . . .	1,728·50	2,420·30	1·40
Ironclad . . . . .	2,040·50	1,441·57	·70
Ironclad South . . . . .	61·00	24·00	·39
Iron Duke . . . . .	40·00	25·70	·64
Keep-it-Dark . . . . .	32·50	73·65	2·26
Marble Bar . . . . .	11·00	15·70	1·42
Pillendinnie . . . . .	1·00	342·00	342·00
Rejected . . . . .	Included under Homeward		Bound.
Robert Bruce . . . . .	112·00	116·92	1·04
Shamrock . . . . .	60·25	142·80	2·37
Stray Shot . . . . .	Included under Augusta.		
Sundry Claims . . . . .	443·80	4,532·29	10·21
Trafalgar . . . . .	30·00	90·00	3·00
True Blue . . . . .	183·25	310·02	1·69
Total . . . . .	10,760·45	24,341·23	2·26

## GENERAL

In the latter end of last year, while in the North-West, a communication was received from Mr. J. Isdell, M.L.A., the Parliamentary representative of the district, containing a request

<sup>1</sup> Alluvial.

<sup>2</sup> Alluvial and dollied.

<sup>3</sup> Does not include alluvial and dollied.

that the tailings in the Marble Bar District be experimented upon by the Department, with the view of suggesting a method by which the large quantity of gold reported to have been lost in previous years could be recovered.

In accordance with instructions, attention was devoted to the question while at Marble Bar, and the heap of accumulated tailings at (a) the Ironclad mine, and (b) on M.A. 1, were sampled by myself and Mr. Talbot, the Field Assistant.

These, on being received in Perth, were dealt with in the official laboratory, and reported on by Mr. E. S. Simpson, as follows :—

“The following are the results of extraction tests made on two samples of tailings collected by you at Marble Bar :—

“G.S.L. 687, IRONCLAD MINE.—These tailings consisted mainly of quartz sand, with a small percentage of clay and iron oxides, a very small amount of pyrites, and a minute trace of copper. No antimony was present. The samples carried 28 per cent. of slimes. Percolation was easy and rapid. Cyanide consumed 0·63 lb. per ton. Assay value of tailings, 4 dwts. 15 grs. per ton ; of residues, 1 dwt. 9 grs. per ton. Extraction, 70·3 per cent. after three days' leaching.

“There are no metallurgical difficulties whatever in the way of treating these tailings by the cyanide process. The question of their successful treatment resolves itself into one of economics solely, viz., whether or not 13s. 9d. (the value of the gold which it is possible to extract) will, under local conditions, do more than pay for the cost of extraction.

“G.S.L. 688, M.A. 1.—These tailings also consist mainly of quartz sand, with a small percentage of clay and iron oxides, a trace of pyrites, a slight trace of antimony, and copper carbonates equal to 0·15 per cent. of copper. The sample contained 28 per cent. of slimes. Percolation was very good. Cyanide consumed was very high, viz., 4·19 lbs. per ton, probably owing to the copper present. Assay value of tailings, 3 dwts. 6 grs. per ton ; of residues, 1 dwt. 22 grs. per ton. Extraction, 41·0 per cent., after three days' leaching.

“It would appear to be impossible to treat these tailings successfully. In the first place they are not rich in gold ; in the second, the copper present causes the extraction to be very low, and the consumption of cyanide so high as to be prohibitive.”

## DIVISION III

### THIRD REPORT, 1905

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#### PART I.—DESCRIPTIVE GEOLOGY

The general reconnaissance of the Pilbara Goldfield, commenced in 1903, was completed at the close of the field season of 1905. On this occasion the portions of the district not previously visited were reached by way of Roebourne, and the Pilbara Goldfield entered by the crossing of the Yule River at Womerina Pool.

Close by Womerina Pool is the site of a small alluvial gold rush some little time ago. The pool itself lies at the foot of a long serrated ridge, which forms a gigantic horseshoe of several miles in length, the southern arm of which returns to the Yule River near Minnaginienna Pool, some miles to the south of Womerina.

At the latter place the banded quartz which constitutes the horseshoe range is of considerable thickness and underlies at a very high angle to the south. At the scene of the alluvial rush near Womerina, the laminated quartz has been subjected to a considerable amount of disruption (Fig. 51). A well marked fault trending generally 156 degrees is seen traversing the banded quartz which forms high cliffs in the vicinity.

A small creek, falling into the Yule River and draining the valley between two readily identifiable beds, has been the one which seems to have carried the bulk of the gold. Judging by the condition and situation of the workings, the gold seems to have been concentrated in the vicinity of the fault which crosses the valley almost at right angles. The laminated quartz veins are associated with quartzites, slates, and cleaved greenstones of the type common to other Pilbara centres.

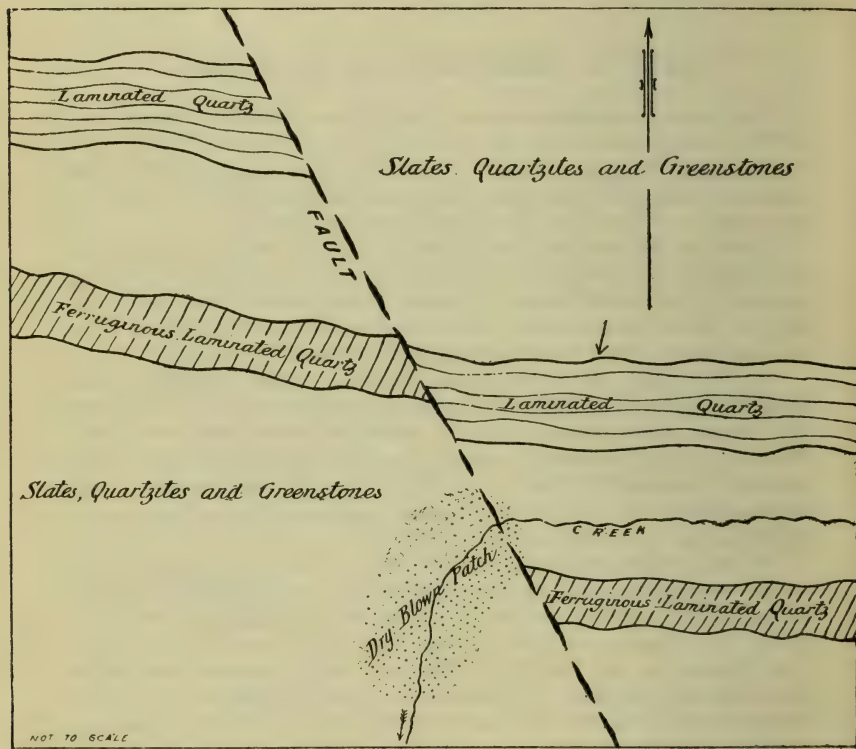
Up the valley between the arms of the horseshoe, the country rock is granite which forms part of that occupying such extensive areas in the district. Where the range is crossed by the track to the Wodgina Tinfield, the slates and other associated rocks give place to granite, which sends out veins and dykes into them.

Considering the identity of the geological structure of this range with other portions of the district in which tin mining has been carried out, there seem good grounds for advising that attention should be paid to prospecting the margin of the intrusive granite in this neighbourhood in the hope of finding tin also.



From the Womerina Range to Wodgina the track passes over nothing but granite of the prevailing type; this, however, gives place in the vicinity of the latter locality to a series of highly inclined metamorphosed sedimentary and igneous rocks. These have been very much folded and faulted, and they occupy a rugged range which rises to considerable altitudes above the general level of the surrounding granite plains. The metamorphic beds are pierced by granite and pegmatite veins, which emanate from the

FIG. 51.



SKETCH PLAN AT WOMERINA POOL. YULE RIVER.

main mass; these rocks are fully described on a later page (p. 256) under the heading of the Wodgina Tinfield.

In certain parts of the Wodgina field, at the Stannum group of leases, the rocks are traversed by an older series of acidic dykes, which have been very much cleaved and sheared, and are intersected by the newer pegmatitic granite veins of the Wodgina type.

The intrusive granite of Wodgina occupies the whole of the watershed of the Yule River to a point at the foot of the

Mungaroona Range, below Cangan Pool, on the western branch of the river, and extends without interruption as far to the eastward as Tambourah and Western Shaw. In the vicinity of Tambourah and Western Shaw, the older crystalline schists, which form the matrices of the auriferous quartz reefs of these centres, again make their appearance and occupy a fairly extensive belt. Everywhere along the margin the granite is found sending out tongues and veins into the schists, and in many cases large lenticular masses of schist have been caught up in the granite. Full details regarding the geology of this part of the field are given on a later page (p. 223) in that portion of the report which includes the descriptions of individual centres.

Leaving Western Shaw *en route* for the Cooglegong Tinfeld, we followed the belt of schists as far to the southward as the junction of the Tambourah and Western Shaw Creeks. A little to the east of this the schists give place to granitic gneiss, which may represent the portions of the older schists which have been absorbed by the intrusive granite.

The granite of Cooglegong occupies a wide expanse of country, and extends over an area of some hundreds of square miles.

From Cooglegong our route lay by way of the Black Range Well, on one of the tributaries of the Shaw. In the vicinity of this the granite is covered by the basal conglomerate of the Nullagine Series, which, with its associated volcanic rocks, occupies the country as far as Just-in-Time, where an auriferous ferruginous conglomerate at the base of the series has been mined. Full details regarding the geology of this centre are given on a later page (p. 249), in that portion of the report which describes the different mining centres.

From Just-in-Time to Marble Bar the route traverses the crystalline schists of the Marble Bar-Yandicoogina belt, which have been fully described in previous reports; hence no further reference need be made thereto in this place.

Mr. H. W. B. Talbot, the Field Assistant, on returning to Roebourne with the horses and equipment, furnished the following report on a traverse from Marble Bar to the Turner River:—

“The route followed was *via* Cooglegong, and, as you had already been over that road, no notes were made regarding the geological structure of the country traversed. From the Shaw River I travelled *via* Dead Bullock Well and Abados Station to Green’s Track.

“Leaving the Shaw River, the track skirts along the southern edge of a bold range for about 4 miles, the country being underlain by granite. The granite then gives place to schists, which have a general strike of nearly north and south. Judging by the veins of granite outcropping at the edges of the schist, the granite would appear to be intrusive into the latter. The road traverses the schist for about 3 miles, when the country rock again consists of granite, which in many places rises into hills

covered with little or no vegetation. When the track leaves the granite it crosses the northern continuation of the Tambourah and Western Shaw belt, which at this point is about 4 miles wide, and consists of slates, quartzites, and fine conglomerates, traversed longitudinally by numerous laminated ferruginous quartz reefs. The general strike of the rocks is in a northerly and southerly direction. After traversing this belt the road emerges into the large granite plain, which occupies such a large area in this portion of the Pilbara Goldfield.

“Near Abados Station several greenstone dykes outcrop and strike about north-north-east. One of these dykes rises abruptly from the plain and, extending for several miles across country, forms a conspicuous feature in the landscape.

“At White Cliffs Pool, on the Turner River, and about 9 miles from Abados, an area of about 1 square mile is occupied by a dark-coloured igneous rock, much weathered, and possessing a schistose structure. Its relation to the granite was not ascertained. At the pool this rock is overlain by a pure white travertine, which, on the west bank of the river, forms cliffs about 40 feet in height.

“From White Cliffs Pool to Green’s Track the road runs close to the Turner River, and the rock seen on the roadside consists solely of granite.

“A description of the country from the intersection of the Turner River by Green’s Track has already been published,<sup>1</sup> and therefore does not need repetition.”

<sup>1</sup> Annual Progress Report of the Geological Survey for the Year 1904. Perth: By Authority, 1905. pp. 147-149.



# GEOLOGICAL SKETCH MAP

OF

PILBARA G. F.

BY

**J. Gibb Maitland**  
GOVERNMENT & GEOLOGIST

AMC

H. W. B. Talbot  
FIELD ASSISTANT

FIELD ASSISTANT

1905



### Scale of Chains

### EXPLANATION OF COLOURS & SIGNS

GRANITE (and its derivatives)

Gr

GREENSTONES ( " their " ).

四

QUARTZ REEFS.

Q

LAMINATED QUARTZ VEINS..

2.2

LINES OF FOLIATION

• • •

### GEOLOGICAL BOUNDARIES .

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EXTINCT MINING LEASES } Name of ..... Corona  
Number of ..... 272

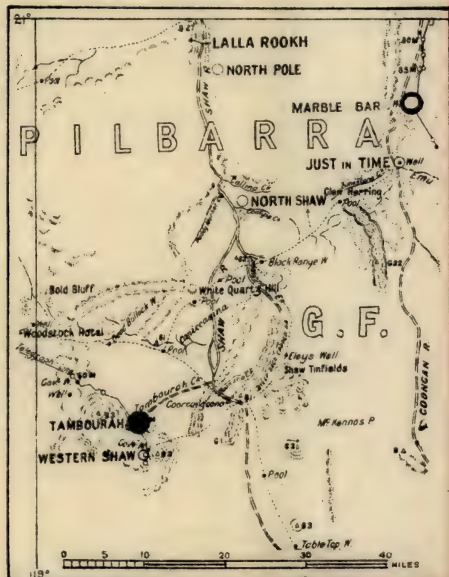
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.) Boundaries of.

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REGISTERED NO OF SPECIMEN .

## LOCALITY MAP.



R H Lewin dec. 19/4/06





## PART II.—DESCRIPTIONS OF INDIVIDUAL MINING CENTRES

### M.—Tambourah

(*With a Geological Sketch Map. Plate XV.*)

The mining centre of Tambourah is situated about 75 miles south-west of Marble Bar, upon the head-waters of the creek, from which it takes its name, and which forms one of the important branches of the Shaw River. The old mail-coach road from Roebourne to Nullagine passes through both Tambourah and Western Shaw.

The mining centre lies just to the west of the junction of the greenstone with the intrusive granite, which extends without any interruption as far as the old Pilbara mining camp (also on the fringe of the granite), about 70 miles to the north-west. The auriferous belt, so far as has yet been proved, extends for about a couple of miles due north and south, at an average distance of about a quarter of a mile east of the granite junction, as may be seen by an inspection of the geological sketch map.

Nineteen gold mining leases were in force at Tambourah during one period of its history, but at the present time there are none, and the locality now presents a very prosaic appearance.

A Government well, 97 feet in depth, had been sunk on the south bank of Tambourah Creek, at the spot indicated on the map. From the bottom of the well a drive had been put in 12 feet north-west. The water, which is estimated at about 100 gallons per hour, proved to be fresh.

The country in the vicinity of Tambourah consists of a series of low undulating hills, which rise to no conspicuous altitudes above the general level of their surroundings.

Firewood and mining timber are not abundant, but doubtless sufficient to supply the wants of a small centre for a few years might be obtained within reasonable distance of Tambourah.

### HISTORY

Very little appears to have been officially recorded of the early history of Tambourah. The Acting Inspector of Mines for the Northern Goldfields, in his report for the year 1894-5, writes of Tambourah Creek:—

Lying also on the outskirts of another vast granite area, which stretches away north-westwards. The character of the country differs from that of Western Shaw somewhat, the hills being low and more rounded. The



formations, too, consist mainly of hornblende-schists, diorite, and opaline. The outcrops of the reefs are small, but they mostly widen out in depth. Very rich stone has been obtained from some of the workings, and the general character of the quartz is very "kindly." Some is highly mineralised with ores of iron, copper, and manganese. From Tambourah Creek north-westwards for some 80 miles along the eastern side of the Yule River there extends a vast area of granite country, apparently reaching back eastwards to the Upper Shaw Country.<sup>1</sup>

The following year the same officer reports:—

With the probability of erection of batteries at the North Shaw, and also at Tambourah Creek, these two very promising centres should soon advance considerably in importance.<sup>2</sup>

The Warden, in his report on the Pilbara Goldfield for the year 1897, informs the Minister for Mines that:—

Tambourah Creek, situated 75 miles south-west of Marble Bar, has a population of about 40. It enjoys the convenience of a post and telegraph office, a wayside house, and two stores. One battery is erected, and a Peruvian mill is being erected. The only Company interested in this district is the World's Fair Mining Co., Ltd., who hold four leases. There are, besides, nine other leases and three protection areas. The yield of gold for the year was 305 ozs. out of 142 tons.<sup>3</sup>

In his report for the year 1901, the Warden writes that:—

Mining matters at . . . Tambourah, Western Shaw, . . . were very dull, only a few miners being employed.<sup>4</sup>

No further mention is made of the progress of Tambourah in the Annual Reports of the Department of Mines since 1901; the field having gradually declined until at the present date it may be said to have been practically temporarily abandoned.

Owing to difficulties connected with obtaining their stone crushed, the owners of the Kirkpatrick Mine, G.M.L. 464, erected in 1898 an arrastra on the granite rise, on the southern bank of Tambourah Creek at the spot shown on the map. It appears, however, that the arrastra did not prove an unqualified success, for though it did excellent work in reducing the ore to a fine powder, it was too slow for the owners.

## GENERAL GEOLOGY

In its geological structure the neighbourhood of Tambourah is comparatively simple, there being practically only two formations within the limits of the area mapped, viz., granite and its derivatives; and greenstone and its transmuted varieties.

### THE GRANITE.

The granite occupies the western portion of the field, and forms the margin of that large mass which extends for considerable

<sup>1</sup> Report of the Department of Mines for the year 1895. Perth: By Authority, 1896, p. 30.

<sup>2</sup> Report of the Department of Mines for the year 1896. Perth: By Authority, 1897, p. 36.

<sup>3</sup> Report of the Department of Mines for the year 1897. Perth: By Authority, 1898, pp. 23-24.

<sup>4</sup> Report of the Department of Mines for the year 1901. Perth: By Authority, 1902, p. 45.

distances to the north, south, and west. The granite is intrusive, and sends out veins into the greenstones, in addition to containing extensive masses of the latter, more especially along its margin.

One very conspicuous mass of intrusive granite, about 8 chains in maximum width, makes its appearance in the Tambourah Queen Lease, and extends due north for a distance of about 30 chains. This mass is traversed by several quartz reefs, one of which intersects both granite and the enclosing greenstone.

In its characters the granite presents much uniformity, a typical example of it [6487] being exposed in the operations connected with the erection of the arrastra on the southern bank of Tambourah Creek. The granite, as developed in this locality, is of a light grey colour, of medium grain, and consists, so far as may be judged by an examination with the unaided eye, of quartz, felspar, and small quantities of a white or pale-green mica. Microscopic examination does not disclose anything of especial note in regard to its structure.

One of the granite dykes which traverses the Western Chief Lease is composed of a rock of much finer grain [6488] than the rest of the granite. The rock has undergone a certain amount of crushing, and in hand specimens presents all the characters of a fine-grained granitic schist (granulite?). Both black and white micas can be recognised by the unaided eye. Examined microscopically the rock is found to consist principally of a fine-grained mosaic of quartz and felspar, through which are scattered numerous larger aggregates of quartz grains. The micas are now represented in the slide by ferrite, though a little sericitic mica can be detected.

Further to the eastward, and in the same dyke [6490], at a greater distance from the granite, the rock is of a much finer grain, and exhibits a much more platy and semi-schistose structure. Under the microscope it presents no essential differences to that previously described, beyond that in the fine quartz-felspar mosaic a marked lineation, which is not at first very conspicuous, can be detected.

#### THE GREENSTONES AND THEIR DERIVATIVES.

The eastern portion of the district is occupied by basic rocks, which, so far as observations have at present been carried, belong to one type, and such differences as they present being brought about by causes operating after their consolidation. All these rocks are affected by foliation, the lines of which have a general trend of north and south, with a very high inclination to the eastward. In some cases the rocks are hornblende-schists, and at others massive greenstones; they are all dark, heavy rocks [6485, 6486, 6489, 6493], and an important characteristic of most of them is the abundance of both brown and green hornblende.

A specimen of the schistose variety [6485] from a mass which has been involved in the granite, near the western margin of the map, when examined under the microscope, is found to consist principally of hornblende, some of which shows the characteristic

prismatic cleavage. The matrix in which the hornblende lies consists chiefly of grains of fresh coloured felspar, showing under crossed nicols lamellar twinning; the felspar contains acicular inclusions of apatite (?). There is a relatively small quantity of iron ore which is in all probability ilmenite.

What appears as a long dyke of greenstone [6486] outcrops on the eastern boundary of the Duke of Wellington and the Corunna Leases; it may, however, be merely an attenuated patch of unmodified greenstone, which has escaped total destruction. Under the microscope, the rock [6486] is found to consist chiefly of hornblende, which has in most cases lost all traces of its original form, and is crowded with inclusions; the felspar is represented by cloudy patches which occasionally contain acicular needles of hornblende and apatite (?). From its mode of occurrence, it seems to indicate that the felspar has undergone a more or less complete molecular reconstruction. The small quantity of iron ore appears to be ilmenite.

The country rock [6493] of the Tambourah King Reef is of a somewhat fine grain and exhibits a rude foliation in hand specimens, and contains a little iron pyrites. Under the microscope, the rock is found to be made up of brown and green hornblende, clear pellucid felspar, and fairly large quantity of iron ore, which seems to be largely ilmenite.

The rock [6489] which occurs in the Government Well is much more foliated than any of the others in the district. In hand specimens the rock exhibits more recognisable crystals, but has the appearance of a somewhat unctuous chlorite schist, and under the microscope no distinguishing features.

No observations were made regarding the effects of the contact metamorphism on the greenstones in the vicinity of the granite junction.

#### THE QUARTZ REEFS.

The quartz reefs are very numerous and occur both in the granite and the greenstones, though they are more numerous in the latter.

The quartz of most of the reefs, as far as can at present be seen, is of white or amber colour; as seen underground by Mr. Inspector Becher, the stone "is heavily mineralised with iron pyrites, arsenical iron pyrites and galena being also present. Above water-level these ores have been mostly converted into oxides, leaving the stone sometimes in a honeycombed state with free gold in the spaces, pointing to the fact that the sulphides have carried gold in combination."

The reefs naturally vary in size within very wide limits; but, from what can be learnt at the present time, it appears that the smaller reefs carry the richer stone, and on the whole it may be said that Tambourah is a field of small reefs.

An inspection of the map, upon which the position of all the



quartz reefs has been laid down with such a degree of accuracy as the scale and the circumstances seemed to warrant, shows that when viewed on the whole they exhibit a rude parallelism coincident with that of the foliation of the district, viz., north and south.

The one which has the greatest linear persistence is that which traverses the Western Chief Leases, and can be followed southward without any break for a distance of about 6000 feet, and may possibly extend farther than the limits embraced by the map.

The reefs are all vertical, or at any rate are inclined at a high angle to the east. The longest reef, viz., the one previously described, passes in its northern portion into a very banded form, identical in every respect with those laminated quartz veins which form such conspicuous features in the geology of other centres in the Pilbara Goldfield and the other mining fields throughout the State.

The quartz reefs of Tambourah have yielded up to the close of 1905 3606·21 ozs. of gold, derived from the milling of 2253·25 tons of quartz, or at the rate of 1·60 ozs. per ton.

It has been shown that the relation between the granite and the greenstone is that the former is intrusive into the latter, and that the quartz veins traverse both series indiscriminately, although they are much more numerous in the greenstone. It necessarily follows from this, and the fact has a very important bearing upon the future of this and other north-west fields, which are geologically identical, viz., that the quartz reefs are likely to be as persistent in depth as deposits of the kind can ever be, and they are not liable to be cut off by the granite as might have been the case had the formation of the reefs preceded the intrusion thereof.

### THE ORE DEPOSITS AND MINES.

For convenience of description, the ore deposits and workings are described in geographical sequence, commencing at the northern end of the field.

BRILLIANT, G.M.L. 410 (formerly G.M.L. 265).—This is an isolated lease lying about a little over half a mile due north of the Corunna, and is in all probability traversed by the extension of that long line of reef which crosses the Duke of Wellington and the Corunna Leases, and has been followed about a quarter of a mile due north up to the boundary of the geological map. No

*Table showing the Yield of the Brilliant G.M.L. 410.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . .	35·00	21·60	·61

work was going on at the date of my visit, hence no inspection of the lease was made. Only a few ounces of gold have been obtained from this property, the details in connection with which are given in the preceding table.

KIRKPATRICK, G.M.L. 464.—This is an old unsurveyed lease, situated about 10 chains north 70 degrees east from the Brilliant Lease, and lies just outside the northern boundary of the geological sketch map (Plate XV.). No work was going on at the date of my visit, and had not been for years, hence the property was unvisited.

The following table gives the official returns from the property, as deduced from official data :—

*Table showing the Yield of the Kirkpatrick, G.M.L. 464.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	88.00	208.50	2.36

CORUNNA, G.M.L. 272.—This 12-acre lease, which adjoins the Duke of Wellington on the north, is traversed by three distinct lines of reef. The westernmost reef, which is coterminous with that in the adjoining lease, outcrops at an average distance of about 80 feet from the western boundary, and can be readily followed along the surface for about 800 feet northwards. This reef has been opened out by an underlay shaft, stated to have been carried down to a depth of about 30 feet, but is inaccessible at the present time. The reef appears to be small, and the prospects are stated not to have been very encouraging. There seems to be good grounds for the belief that this reef may be the northern extension of that outcropping in the Tambourah King Lease (*q.v.*).

Two hundred and fifty feet east from the previously mentioned shaft is another, sunk to a depth, of which there is no record, upon one of the most persistent lines of reef occurring within the limits of the country examined. This reef, which traverses the whole length of the lease, at an average distance of about 100 feet from the eastern boundary of the property, can be followed continuously along the surface for a distance of about 3000 feet, and for a considerable distance beyond the limits of the geological map (Plate XV.). The reef, which is small, is encased in the planes of foliation of a very hard hornblende schist.

Three hundred and forty feet to the south-east of the westernmost shaft is another sunk to a depth, of which there appears to be no record, on a well-defined quartz reef, underlying east at a very high angle. The reef, which is small, can be followed along the strike for about 500 feet, and extends into the adjoining lease on the south.

Another small but well-defined reef outcrops at about 220 feet

from the south-west angle of this lease, not far from the boundary of the intrusive granite. This reef has been opened out by a prospecting shaft, sunk however only a few feet; it can be readily followed along its outcrop for a distance of about 500 feet.

DUKE OF WELLINGTON, G.M.L. 264.—The southern portion of this 12-acre lease is traversed by Tambourah Creek, which in this part of its course has a width which varies from 150 to a little over 200 feet.

Three distinct lines of reef traverse the property in a general north and south direction. At the time this property was at work, in the year 1896, these different reefs were respectively known by the names of the "King," the "Intermediate" and the "Chief," in the belief, for which there seem to be some sound geological reasons, that they represented the northern extension of the main lines of reef traversing the Tambourah King and the Western Chief Leases.

The westernmost reef (The King Line) is described by Mr. Becher as consisting of three small parallel leaders outcropping within a space of 20 feet, and can be traced right across the property. This reef has been opened up at intervals along its outcrop over a distance of about 200 feet. The reef is enclosed in a dark micaceous schist and underlies at a very high angle to the east. A shaft has been sunk upon it to a depth, of which there is no record; at the surface the reef was only a few inches in thickness, but at a depth of 30 feet (at which depth good drinkable water was encountered) it had increased to 24 inches. This shaft, as are all the others on the field, is inaccessible. Another shaft has been put down upon the same reef, at a point about 40 feet northwards and attained a depth of 25 feet; from this depth it is stated that a south drive was commenced with the object of connecting with the first mentioned shaft.

No other work of any importance appears to have been done upon the other lines of reef.

THE WESTERN CHIEF, G.M.L. 567 (l. 536).—This lease of 12 acres, embracing the original prospecting area granted to Mr. E. Barnes, was taken up in its present shape by Mr. J. S. Forbes in the year 1898 under the same name.

The reefs worked in the adjoining property (the Western Chief) on the south traverse the whole length of the lease, and judging by the condition of the surface, a considerable amount of work must have evidently been carried out. The ground having been abandoned since the year 1901, all the workings being inaccessible (as well as there being no plans of the mine lodged with the Government), no information as to the condition of affairs prevailing underground is available.

Two well-defined quartz reefs traverse the whole length of the lease; and a well marked band of laminated quartzite outcrops at a distance averaging from 20 to 60 feet to the east of the main reef, and continues northwards without any break as far as the southern



bank of the Tambourah Creek. This band, which forms an important feature in the structural geology of the field, can be followed southwards through the Western Chief and the Alexandra, where it merges into a quartz reef; it thus has a continuous outcrop of over 6000 feet within the area embraced by the map which forms Plate XV.

The westernmost reef, which is continuous from the Western Chief Lease, enters the property at a point on the southern boundary, about 140 feet east from the peg at the south-west angle of the lease, and can be followed without any break northwards, where it passes into vacant ground at a point on the northern boundary about 340 feet east of the north-west corner. It, however, has only been opened up at one spot 140 feet distant from the northern boundary of the lease; here a pothole but a few feet deep exposes a little over 12 inches of a somewhat ferruginous quartz. The main reef, which is parallel to this one, and about 100 feet to the east of it, is likewise continuous throughout the whole length of the property. The reef has been opened up by seven or eight shafts, the positions of which are shown on the map. These shafts having all fallen in, are not now accessible.

*Return showing the Yield of the P. A.*

Year.	Ore Treated.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	<sup>1</sup> 103·00	<sup>2</sup> 103·00	1·00
1898 . . . . .	<sup>1</sup> 48·00	72·00	1·50
1898 . . . . .	<sup>3</sup> 23·00	38·60	1·67
Total . . . . .	174·00	213 60	1·22

The following table gives the yield of the Western Chief reef in so far as such can be obtained from official sources:—

*Table showing the Yield of the Western Chief,  
G.M.L. 567 (l. 536).*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	183·00	225·00	1·23
1899 . . . . .	363·00	416·75	1·14
1900 . . . . .	108·00	122·15	1·13
Total . . . . .	654·00	763·90	1·16

What is known as the P. A. is now embraced within the limits of the Western Chief Lease, and, according to the issues of the

<sup>1</sup> Vide *Northern Public Opinion* for 25th June 1898.

<sup>2</sup> The paper states that the 103 tons yielded "a little more than an ounce per ton."

<sup>3</sup> Vide *Northern Public Opinion* for 20th August 1898.

*Northern Public Opinion*, during 1898, 174 tons of ore yielded 213·60 ounces of gold. The details are given for what they are worth in the preceding table; in all probability, however, these amounts have been included in the yield of the Western Chief Lease for 1898.

WESTERN CHIEF No. 1 SOUTH, G.M.L. 568 (l. 258).—This 12-acre lease, which occupies the central position of the Tambourah properties, was originally taken up in the year 1895 by Messrs. Murcott and others, under the name of the Western Chief, and numbered G.M.L. 258. On being abandoned it was retaken up by Mr. J. S. Forbes, under the same boundaries, and registered under the number and name by which it is at present known. It is much to be regretted that the name of the lease has been altered, as great confusion is apt to arise on the part of the general public, more especially in cases in which personal acquaintance with the district is wanting.

Near the western boundary of the lease and on the high ground the outcrop of a remarkably well-defined quartz reef can be traced right across the whole length or breadth of the property. This reef has been opened out at one spot only, distant about 140 feet from the northern boundary of the ground. Here at a spot where the reef traverses a dyke of what is now granitic schist, a vertical shaft has been sunk to a depth of 10 feet. The northern face of the shaft exposes 2 feet 6 inches of quartz inclined at an angle of 75 degrees to the east. The footwall of the reef is a micaceous granitic schist (?), whilst the hanging wall is a dark micaceous schist. The mica schist contains stringers of quartz, whilst the reef itself occurs along the bedding (or foliation) planes. As seen underground in this shaft the impression left on the mind is that the reef is merely another phase of the silification of the country rock, along a well-defined line of weakness. The quartz is white and certainly does not present a promising appearance. Mr. Inspector Becher's notes indicate clearly that the quartz of this reef is "poor."

Prospecting operations have apparently been centred upon the reef lying about 60 feet to the eastward. This reef seems to have been exploited by four shafts, the positions of which are shown upon the map which forms Plate XV.

Mr. Becher gives several particulars with regard to the workings on this lease; it is unfortunately not quite clear which of the shafts shown upon the map are those to which his descriptions refer. As these observations (1896), which are those of an eyewitness, may have some value, his words are quoted *in extenso*:—

"Upon a well-defined reef near the main reef (*i.e.* the westernmost reef) an underlay shaft has been sunk to water level, 75 feet. At the 60-foot level a drive is being commenced north; here the reef shows about 18 inches of quartz; the average width of all stone showing being about 10 inches. About 25 tons of stone lie at grass, a rough sample from which gave a 2 oz. prospect. The

reef strikes north 20 degrees east and underlays east at an angle of 70 degrees. On the same line of reef 80 feet to the northward another shaft has been sunk 25 feet. Down to water level the ground on this line is a soft decomposed hornblende schist, and at water level becomes harder. On a line farther east a vertical shaft has been sunk 54 feet to cut the reef in depth, but failed to do so, and a crosscut of 10 feet had to be made. A crosscut of 40 feet has also been made west to cut a rich leader prospecting well on the surface. On this same line farther south, an underlay shaft has been put down 35 feet, the stone averaging eight inches. Rough sample along this line gave a 3 oz. prospect (said to be exceptionally good). Twenty tons at grass."

Another well-defined reef outcrops about 220 feet east of that last described, and three shafts have been put down upon it at positions indicated on the map. It is possible that the latter portions of Mr. Becher's descriptions refer to this line; the shafts, however, are at the present time absolutely inaccessible.

*Table showing the Yield of the Western Chief No. 1  
South, G.M.L. 568 (l. 258).*

Year.				Ore Crushed.	Gold therefrom.	Rate per Ton.
				Tons.	Ozs.	Ozs.
1890	.	.	.	72·00	79·17	1·09
1900	.	.	.	30·00	40·00	1·33
1901	.	.	.	...	<sup>1</sup> 130·14	...
Total				102·00	119·17 <sup>1</sup> 130·14	1·16

ALEXANDER, G.M.L. 255.—This is a 9-acre lease, which adjoins the Western Chief on the south. As may be seen by an inspection of the geological map (Plate XV.), the lease is traversed by the same lines of reef as outcrop in the Western Chief and the Young Australia. The principal mining operations appear to have been concentrated upon the southern extension of the most easterly of the Western Chief Reefs. A vertical shaft, stated to have been 47 feet in depth, has been sunk on this reef at a point about 180 feet from the northern boundary. This shaft is inaccessible, but the late Mr. Inspector Becher's notes state: That the reef averaged from 6 to 8 inches in thickness; that the stone prospected well throughout; that a "rough sample gave a 5 ozs. prospect." A drive had been put in to the south from the foot of the shaft, where the stone seemed to be increasing in size, but no particulars are available respecting it.

YOUNG AUSTRALIA, G.M.L. 261.—A 12-acre lease lying about 120 feet north of the Western Hero Group. This property

<sup>1</sup> From tailings.



is traversed by a well-defined quartz reef (which the field evidence points to being the northern extension of the east reef of the Western Hero No. 1 North), outcropping at an average distance of about 200 feet from the eastern boundary of the lease. The reef has been "open-cut" for about 480 feet along its outcrop, and an inaccessible shaft put down on it at a point about 200 feet south from that peg on the northern boundary which separates G.M.Ls. 255 and 341. A good deal of stone must evidently have been taken out from this reef, which can be followed into the adjoining lease 341 for a distance of about 400 feet. Parallel to and about 120 feet west from the Young Australia is another quartz reef of the same type, which can be followed with more or less interruption along the outcrop for a distance of about 460 feet from the northern boundary of the lease.

WESTERN HERO, G.M.L. 253 (formerly Kushmattie, G.M.L. 455).—A 6-acre lease, the most southerly of the whole group at Tambourah, and situated about 70 chains south from the Government Well. A well-defined though small quartz reef extends across the whole length of the lease, outcropping at an average distance of about 160 feet from the western boundary. The reef has been opened up by four shafts, all of which, however, are at the present time inaccessible. Just outside the southern boundary of the lease a tunnel has been put in for a few feet northwards along the reef, and about a foot of stone exposed. The total length of the outcrop of the Western Hero reef, as exposed within the limits of the geological sketch map (Plate XV.), is about 1200 feet. A parallel reef to this outcrops for about 100 feet to the west, and occupies the surface for about 300 feet, adjoining the western boundary and near the north-west angle of the lease. It has been opened out by an inaccessible shaft situated about 200 feet south of the northern boundary of the lease.

*Table showing the Yield of the Western Hero, G.M.L. 253  
(formerly Kushmattie, G.M.L. 455).*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1897 <sup>1</sup> . . . . .	86·00	193·00	2·24
1898 . . . . .	54·50	78·65	1·44
Total . . . . .	140·50	271·65	1·22

WESTERN HERO NO. 1 NORTH, G.M.L. 254.—A fairly well-defined reef traverses the full length of the lease at an average distance of about 120 feet from the eastern boundary. The reef is

<sup>1</sup> The *Northern Public Opinion*, in its issues of the 6th and 13th November 1897, gives returns which indicate that during that year 134 tons of ore crushed yielded 337·15 ozs. of gold, or at the rate of 2·51 ozs. per ton.

parallel to, and a few feet east of, the Western Hero Main Reef. Not much can be seen at the present time of the reef, and the shaft by which it was exploited is now inaccessible.

TAMBOURAH KING, G.M.L. 252.—This 12-acre lease adjoins the Western Chief on the west, and lies between it and the western tributary, which flows into Tambourah Creek at the Government Well. A well-defined reef, with a northerly trend traverses the whole length of the property, and has been opened up at one time or another by four now disused vertical shafts. The reef is said to have averaged from 8 to 12 inches in width near the surface.

At the time this property was visited, no work was going on, and what seems to have been the main shaft was inaccessible. A Tremaine Mill, which had been moved from the White Angel Mine, near Marble Bar, is erected on the property close to the main shaft.

According to the late Mr. Inspector Becher's notes, the development on the property consisted at the date of his visit of:—

“No. 1 Shaft.—42 feet vertical.

“No. 2 Shaft.—25 feet vertical; driving south to meet level from No. 3; now in 12 feet, very little stone in the face.

“No. 3 Shaft.—25 feet vertical, with a level to connect with No. 2, now driven 25 feet; at the bottom of the shaft, good stone 14 inches in width to be seen.”

At one period in the early history of the mine, 5 tons of quartz were carted to the nearest battery at Pilbara (75 miles distant), and are said to have given a return of 6 ozs. 13 dwts. of gold per ton; from which it may reasonably be inferred that a very rich shoot was met with.

The *Northern Public Opinion* of 12th February 1898, gives an account of the reef in the Tambourah King as it appeared in the lower levels of the mine, and as this is the only information as to the behaviour of the reef underground it is quoted *in extenso*:—

“From the vertical shaft in the King, the reef was struck at about 40 feet, and the stone is of splendid quality, though highly mineralised, so much so that although gold shows freely in it, treating it with the appliances which will be available here can hardly prove successful. . . . The country is hard and the reef but of small size—about 6 inches where struck—but getting it in this hard country goes far to prove the continuance and permanence of the reefs about here, and shows too that the gold is going down as well as the ore-body. There has not been much occasion to doubt the permanency of the Tambourah Reefs, as in no less than six or seven shafts hard country has been met with, and in each case the reefs continue, whilst in some they increase in width and carry the gold down, although soon as the hard ground is met with the nature of the ore alters naturally, and becomes more or less mineralised, whereas before the hard ground is reached the lodes contain comparatively little mineral and are very free to treat.”

The following table gives the output of the Tambourah King Lease, so far as such can be obtained from official data :—

*Table showing the Yield of the Tambourah King,  
G.M.L. 252.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1897 . . . .	56·00	112·00	2·00
1898 . . . .	30·00	42·00	1·40
Total . .	86·00	154·00	1·79

TAMBOURAH QUEEN, G.M.L. 262.—A 6-acre lease lying in vacant ground between the Corunna and the World's Fair properties. The surface of the lease is occupied by hornblende and micaceous schist, which are everywhere inclined at very high angles to the east, with a general north and south strike.

A very conspicuous granite dyke occupies a considerable portion of the eastern area of the lease, attaining a maximum width of about 200 feet along the northern boundary of the property. A well-defined though small quartz reef, having an outcrop of about 900 feet in length, lies at an average distance of about 100 feet from the western boundary of the lease, and has been more or less perfunctorily worked. Judging, however, from the present condition of the surface, it would seem that very little stone can have been raised. The reef underlies at a high angle to the east, and occurs along the bedding (foliation?) planes of the schist.

WORLD'S FAIR No. 1 NORTH, G.M.L. 259.—This 12-acre lease adjoins the World's Fair on the north. There are one or two short reefs outcropping on the property, but no work seems to have been done upon any of them. The country rock is basic schist of the usual type.

WORLD'S FAIR, G.M.L. 256.—The northern portion of this 12-acre lease is situated on the high ground to the north of and adjoining Tambourah Creek. The whole surface of the lease is occupied by hornblende schist of the usual type, and inclined at very high angles to the east. Two well-defined reefs traverse the property; it is, however, only upon the eastern reef, which lies at an average distance of 150 feet from the western boundary of the lease, that any work has been done. A fair amount of prospecting work has been carried out upon this reef, which can be followed by its outcrop for a distance of a little over 500 feet.

A shaft has been sunk somewhere near the centre of the outcrop at a point about 450 feet from the southern boundary of the lease. This shaft is at the present time inaccessible, but from the



notes of the late Mr. Inspector Becher, it appears to have been carried down 25 feet, and levels driven north and south from a depth of 20 feet for an unstated length. The same writer states: "Near the surface in this shaft, very rich specimen stone was found, but was apparently confined to a patch, and the owners do not apparently consider the prospects sufficiently encouraging to continue work."

So far as may be seen on the surface the reef is very thin, in no place exceeding 12 inches; the stone is somewhat ferruginous, suggesting pyrites at a depth.

The files of the *Northern Public Opinion* give the following records regarding three crushings from the World's Fair in 1898, viz., July 2nd, 100 tons for 108 ozs., and 98 tons for 208 ozs.; whilst on August 20th, 60 tons are stated to have yielded 35 ozs. These three crushings total 258 tons for 351 ozs., or at the rate of 1·36 ozs. per ton, which is considerably less than the official return for the year in the following table. It may be noted, however, that this table gives the aggregate yield of the three leases held by the then World's Fair Gold Mining Company, viz., 254, 255, and 258, so that there are no means of knowing whether the whole of the gold so recorded was actually obtained from the World's Fair Lease, G.M.L. 256.

*Table showing the Yield of the World's Fair G.M. Co., Ltd.,  
G.M.Ls. 254, 255, 258.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
1898 . . . . .	412·00	505·60	1·22

GOLDEN CHEERS, G.M.L. 275.—A very large proportion of the surface of this lease, upon which little or nothing appears to have been done, is occupied by the sandy bed of Tambourah Creek, which in this portion of its course averages about 200 feet in width. There are, however, strong geological grounds for believing that the Charlie and the World's Fair Reefs may traverse the centre of the lease, but if so the outcrop can only be small and ill-defined.

CHARLIE, G.M.L. 257.—The main Charlie Reef, of which the World's Fair (*q.v.*) may be the northern extension, extends through the whole length of the lease, outcropping at no very great distance from the western boundary of the property.

Prospecting operations, however, appear to have been confined to a small reef, the outcrop of which can be seen entering the lease on its southern boundary at a point about 140 feet from the peg forming the south-west angle of the property. An inaccessible

shallow shaft has been put down at the southern end of the reef, but there is little or nothing to be seen at the present time.

**FEDERAL, G.M.L. 456.**—A fair amount of prospecting work appears to have been carried out on two other parallel reefs, which outcrop at average distances of 100 to 200 feet east of the main Charlie Reef, in the ground lying between G.M.Ls. 260 and 257, and at one time embraced by G.M.L. 456. Shafts have been sunk upon each of the reefs at localities which are indicated on the geological sketch map, Plate XV.; but they are inaccessible, and no information is available at the present time regarding them.

The following table gives the yield of this lease so far as can be ascertained from official data :—

*Table showing the Yield of the Federal, G.M.L. 456.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1898 <sup>1</sup> . . . . .	Tons. 11·00	Ozs. 15·25	Ozs. 1·38

**EASTERN HERO No. 1 SOUTH, G.M.L. 260.**—A 6-acre lease adjoining the Young Australian No. 1 North, G.M.L. 341 on the north. A short though well-defined white quartz reef outcrops near the centre of the property at an average distance of about 100 feet from the western boundary of the lease. The reef underlies to the west at a high angle, as is the case with most of the quartz reefs of Tambourah. What may be called the extension of this reef makes its appearance a short distance northwards, where it leaves the lease at a point on the northern boundary distant about 120 feet east from the peg forming the north-west angle of the lease. This reef, which is remarkable for its longitudinal persistence, can be followed northwards right through the Charlie, G.M.L. 257, for a distance of about 1500 feet.

**YOUNG AUSTRALIAN No. 1 N., G.M.L. 341** (formerly Old Australian, G.M.L. 465).—This 9-acre lease adjoins the Young Australia on the north and the Alexandra on the east. Virtually no work seems to have been done upon the ground. The Young Australia reef enters the lease at the south-west angle of the property, and can be followed to a point about 500 feet north, where the granitic dyke, which traverses the surface, crosses its outcrop almost at right angles to the strike of the reef. North of this dyke a well-defined band of laminated quartzite, with secondary silica, makes its appearance, and can be followed without interruption to the northern boundary of the lease and for a distance of about 800 feet farther.

<sup>1</sup> The issue of the 12th June 1897, of the *Northern Public Opinion*, gives a return for that year of 19·50 tons yielding 21·00 ozs., or at the rate of 1·07 oz. per ton. It is probable that these figures are included in the official returns from Sundry Claims in 1897.

*Table showing the Yield of the Young Australian No. 1 N.  
(formerly the Old Australian, G.M.L. 465).*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
1898 . . . . .	Tons. 51·50	Ozs. 70·10	Ozs. 1·36

QUARTZ CLAIM 148 (McGrath and Anderson).—A quartz claim, the exact situation of which is not now identifiable, produced in 1904, 43·71 ozs. of gold.

SUNDRY CLAIMS.—The following figures arranged in a tabular form annually give the yield of the various claims which have been held at different times, but which cannot be located on the map at the present time. It is more than likely that some at any rate embraced the areas covered by the leases referred to in the previous pages.

*Table showing the Yield of Sundry Claims at Tambourah.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Gross Ozs.	Ozs.
1897 . . . . .	23·00	33·65	1·46
1898 . . . . .	128·75	{ 197·40 1 20·00	1·53
1899 . . . . .	436·50	{ 590·95 2 50·00	1·35
1900 . . . . .	51·00	{ 89·20 2 215·00	1·75
1901 . . . . .	...	2 25·00	...
1902 . . . . .	...	Nil	...
1903 . . . . .	...	Nil	...
1904 . . . . .	...	3 2 43·71	...
1905 . . . . .	...	Nil	...
Total . . . . .	639·25	{ 911·20 1 20·00 2 333·71	1·42

<sup>1</sup> Dollied and specimens.

<sup>2</sup> Alluvial.

<sup>3</sup> Fine ozs.





THE HON H. GREGORY M.L.A.  
Minister for Mines.

GEOLOGICAL SKETCH MAP  
OF

**WESTERN SHAW**

**PILBARA G.F.**

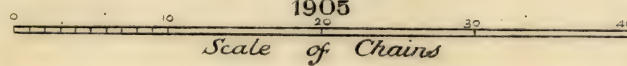
BY

**G. Gibb Mailland**  
GOVERNMENT GEOLOGIST

AND

**H. W. B. Talbot**  
FIELD ASSISTANT

1905



EXPLANATION OF COLOURS & SIGNS

ALLUVIUM	
GREENSTONE (and its derivatives)	
GRANITIC SCHIST	
QUARTZ REEFS	
LAMINATED QUARTZ VEINS	
FAULTS	
GEOLOGICAL BOUNDARIES	
EXTINCT MINING LEASES	

LOCALITY MAP







*Synoptical Table showing the Yield of the Tambourah  
Reefs up to the end of 1905.*

Name of Reef.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Brilliant . . . .	35·00	<sup>1</sup> 21·60	·61
Federal . . . .	11·00	15·25	1·38
Kirkpatrick . . . .	88·00	208·50	2·36
Kushmattie . . . .	140·50	271·65	1·22
Old Australian . . . .	51·50	70·10	1·36
P.A. . . . .	...	<sup>2</sup>	
Quartz Claim 148 . . . .	...	<sup>3</sup> 43·71	
Sundry Claims . . . .	639·25	<sup>4</sup> 1,264·91	1·42
Tambourah King . . . .	83·00	154·00	1·79
Tambourah United <sup>5</sup> . . . .	34·00	37·68	1·10
Western Chief . . . .	654·00	763·90	1·16
Western Chief No. 1 S . . . .	102·00	<sup>6</sup> 249·31	1·16
World's Fair . . . .	412·00	505·60	1·22
Total . . . .	2,253·25	3,606·21	1·60

## GENERAL

An impartial observer cannot fail to be struck with the backward state of the district considering the short period of its existence. The number of shafts in close proximity, upon one of the properties, the Western Chief, seem to imply that prospecting operations were hardly carried out in the most judicious manner and a good deal of unnecessary work was done in consequence.

Firewood and timber for mining purposes are not abundant, but there is little doubt that careful search would result in the discovery of sufficient in the vicinity to meet the requirements of a small field for a few years.

So far as can be ascertained there seems to be a fair water supply to be obtained at a shallow depth, but whether such would prove sufficient to withstand a constant draft upon it, there is no evidence.

## N.—Western Shaw

*(With two Geological Sketch Maps, Plates XVI. and XVII.)*

The mining centre of Western Shaw lies about 5 miles to the south-east of Tambourah, and like it is situated on the old mail route to Roebourne. At one period of its history, Western Shaw

<sup>1</sup> Gross ounces.

<sup>2</sup> Returns probably included under the Western Chief Mine.

<sup>3</sup> Fine ounces. Dollied and specimens.

<sup>4</sup> Includes 20 ozs. of dollied and specimens and 333·71 ozs. of alluvial.

<sup>5</sup> Exact locality unknown.

<sup>6</sup> Includes 130·14 ozs. from tailings.



was connected with the main telegraph system of the State. The relative position of Western Shaw is shown on the geological sketch map, Plate XVII., which also indicates in a general way the situation of the field with respect to the boundary of the intrusive granite, which is continuous from Tambourah.

The backbone of Western Shaw is formed of several parallel rugged and broken razor-backed ridges, which rise to heights about 200 feet above the general level of the country, and form very conspicuous features in the landscape. These ridges trend generally north and south, and it is upon the slopes of the westernmost that the principal prospecting and mining operations have been hitherto carried out.

### HISTORY

The history of Western Shaw as a mining centre appears to have commenced with the rush of 1891, and an immense amount of alluvial gold was won by the dryblowers in the many gullies which traverse the country. As a reefing centre, however, its history dates from 1894, and as has been the case with most of the North-West mining fields, the district has had a somewhat chequered career.

The late Mr. Becher, at one time Acting Inspector of Mines for the Northern Goldfields, in his report to the Government on the district for the year 1894-5, remarks:—

“The Western Shaw, although a field which has been well known for many years for its alluvial gold, is one of the new reefing fields coming quickly to the fore. The general character of the country lying on the outskirts of the granite is most attractive in its rugged nature and geological conditions. Immense quartzite or quartz jasper dykes form the crests of ranges of diorites, opaline, slates, and schists, all having a general uniform bearing or strike slightly west of north. The strata are much upheaved and underlie westwards. Many large well-defined and continuous reefs are to be seen, and a considerable amount of work is being done on good stone. During the year several rich finds have been made.”<sup>1</sup>

In his report for the following year, Mr. Becher states that:—

“At Western Shaw considerable progress has been made by the Imperial West Australian Corporation, who have erected a 10-head battery on their property.”<sup>2</sup>

The Warden in his report on the Pilbara Goldfield for 1896, mentions:—

“A battery is now being erected at Western Shaw, and the few parcels of stone that have as yet been crushed for the battery owners themselves, and for some of the surrounding leaseholders,

<sup>1</sup> Annual Report of the Department of Mines for the year 1895. Perth: By Authority, 1896, p. 30.

<sup>2</sup> *Ibid.*, for the year 1896. Perth: By Authority, 1897, p. 36.



THE HON. R. GIBB M.L.A.  
Minister for Works

GEOLOGICAL SKETCH MAP

OF

TAMBOURAH & WESTERN SHAW

PILBARA G.F.

BY

J. Gibb Maifland

GOVERNMENT GEOLOGIST

H. W. B. TACBOT

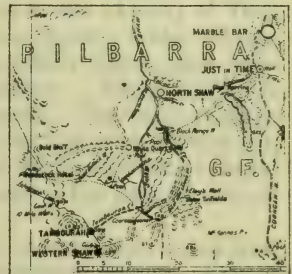
FIELD ASSISTANT.

1905

Scale of Chains

EXPLANATION OF COLOURS AND SIGNS

ALLUVIUM	Yellow
GRANITE	CR
GRANITIC SCHIST	GR. I.
GREENSTONE (and its derivatives)	GR. I.
METAMORPHIC UNITS, FINE CONGLOMERATES, &c.	GR. I.
QUARTZ REYS	GR. I.
LAMINATED QUARTZ VENS	GR. I.
FAULTS	GR. I.
GEOLOGICAL BOUNDARIES	GR. I.



Approximate Boundary

Disused

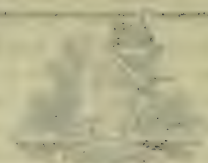
Telegraph

73 M.P.

74 M.P.

75 M.P.

82



WILLIAM HARRISON & SONS, BOSTON.

Printed and Published by

W. HARRISON & SONS,





have yielded good returns and proved the properties to be more than payable."<sup>1</sup>

In his report for the following year, the Warden mentions that the population of the mining centre amounted to twenty persons, that there were six mining leases in existence totalling 78 acres, and held by one company, and that the gold yield was 1032 ozs., derived from the milling of 1140 tons of stone.<sup>2</sup>

No further mention of Western Shaw appears in any later Annual Reports of the Department of Mines.

The field has suffered a gradual decline, until at the present time it is practically abandoned.

### GENERAL GEOLOGICAL FEATURES

In its salient geological features, Western Shaw presents many important points of resemblance to the mining centre of Warrawoona.<sup>3</sup>

The geological formations of the area embraced by the geological sketch map, Plate XVI., are represented by a series of greenstones and greenstone schists, which form the southern extension of those at Tambourah.

To the eastward of the greenstones and in the vicinity of Trig. Station B 2, these are succeeded by a series of silky acidic schists, grits, quartzites, and fine conglomerates, which latter have been subjected to considerable dynamic alteration. These beds are vertical, and trend generally north and south. The exact relation which the schists bear to the greenstones has not been worked out.

The greenstones are traversed by dykes of granitic schist [6491] which have a general parallelism to the trend of the main structural features of the district.

The rocks of the field are like many other of the north-west mining districts, traversed by veins of laminated quartz. Two of the most important of these have been laid down on the map with a reasonable degree of accuracy. One very conspicuous band traverses the whole length of the area mapped, viz., about  $2\frac{1}{2}$  miles, and forms the centre of what may be called the main auriferous zone, which latter is indicated by the long line of leases. The laminated quartz veins are traversed by faults, one of which has a horizontal displacement of about 600 feet. This fault, which is well-marked on the surface, and appears to be a reverse fault, has a general strike of north-west and south-east.

Most of the watercourses in the district are, as may be seen by a reference to the map, occupied by a varying width of alluvium, some portions of which have been very extensively worked, and, from all accounts, a fair amount of alluvial gold would appear to have been obtained therefrom. So far as has at present

<sup>1</sup> Loc. Cit., p. 59.

<sup>2</sup> Annual Report of the Department of Mines for the year 1897. Perth: By Authority, 1898, p. 24.

<sup>3</sup> Bulletin No. 20, pp. 57-73. Perth: By Authority, 1905.

been ascertained, the alluvial deposits do not attain any great thickness.

A Government Well has been sunk in the centre of the alluvial flat, a little to the north of the 75-mile post on the old telegraph line, to a depth of 37 feet, and yields a supply of about 400 gallons of good, fresh water per day. There is no information as to the thickness of alluvium in this well.

There are several well-defined quartz reefs in the area under investigation, the longest of which has a continuous outcrop of about 1200 feet; whilst another to the east is represented by four well-marked veins, connected by thin threads of quartz, may be said to be about 2500 feet long.

From what can be seen at the present time, the quartz reefs seem to conform to the foliation planes of the schists, &c., and may, perhaps, on that account, be best described as bedded veins. The quartz is generally very white and milky in colour, and is occasionally very honeycombed, due to the decomposition of iron pyrites.

The gold is said to have been very coarse, and as might have been expected, occurred most plentifully in the honeycombed quartz.

#### THE ORE DEPOSITS AND MINES.

No mining work of any description was being carried on at the date of my visit to the district, though such mines as were open to inspection were visited, and full descriptions of them are given below.

When operations were in full swing, seven of the thirteen leases in existence on the field were held by the Imperial W.A. Corporation, and a considerable amount of development work had been done. In order to facilitate the company's operations, tram-lines of 35 chains and 70 chains in length had been laid down from the leases 214 and 213 to the battery site on the western boundary of G.M.L. 291. For convenience of description the mines and other workings are described in geographical sequence, commencing at the northern end of the field.

TRAFALGAR, G.M.L. 338 (*vide* Plate XVI.).—This 12-acre lease is situated about  $1\frac{1}{2}$  miles north of the Government Well on the eastern side of the range which forms the main axis of Western Shaw.

Two very small quartz veins, striking north-east and dipping west, had been opened up by trenching; the veins averaged about 8 inches in thickness. A vertical shaft 75 feet deep had been sunk, and at 45 feet levels driven 30 feet north and south respectively.

The two reefs mentioned above are stated to have been met with on each wall, and their average thickness proved to be about 8 inches. A second shaft had been sunk to a depth of 40 feet

at a spot somewhat farther to the south, but no particulars concerning it are available.

The quartz of the veins in this lease is stated to have been of a white colour, and contained small quantities of iron and copper pyrites.

The following table gives the yield of this property, so far as such can be obtained from official data :—

*Table showing the Yield of the Trafalgar, G.M.L. 338.*

Year.	Ore Treated.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Prior to 1897 . . .	6·00	36·00	6 00
1897 <sup>1</sup> . . . . .	24·00	54·00	2·25
Total . . . . .	30·00	90·00	3·00

PINK EYE, G.M.L. 340.—A 12-acre lease lying some little distance to the south of that last described is traversed by four short, but well-defined quartz veins encased in a talcose and chloritic schist. The westernmost reef, which is by far the longest of any, having a length of about 450 feet, is the one upon which most work has been done. Two vertical shafts, connected by a drive at 40 feet, have been sunk to depths of 50 and 40 feet respectively upon the reef, which is stated to have attained an average thickness of about 1 foot 6 inches, and dipping at a high angle to the east. At the time the mine was at work and visited by the then Inspector of Mines, Mr. Becher, there were about 150 tons of ore at grass awaiting crushing. No official record, however, is available of the yield of the stone, which is in all probability included in that of Sundry Claims from the Tambourah district, given on a previous page.

THE IMPERIAL W.A. CORPORATION, LTD.

Gold Mining Leases . .	{	291, W. Shaw No. 1 N.
		214, W. Shaw Reef.
		290, W. Shaw No. 1 S.
		428, General Gordon No. 1 N.
		230, General Gordon.
		215, W. Shaw Consolidated
		213, W. Shaw Extended.
		124,

WESTERN SHAW REEF, G.M.L. 214.—The principal workings on this 12-acre lease have been carried out on two short parallel veins, which outcrop near the summit of the hill on the eastern boundary of the property. These two reefs have outcrops about 200 feet in length, and lie about 20 feet apart. The reef had

<sup>1</sup> The files of the *Northern Public Opinion* for June 5th, 1897, give the yield as being 24 tons for 83 ozs., or at the rate of 3·46 ozs. per ton.



been worked by a tunnel driven on a bearing of 59 degrees 30 minutes from near the base of the western side of the range. The total length of the tunnel is 262 feet, and struck the reef at 200 feet from its mouth; the first few feet in the tunnel expose what appears to be a compressed greenstone, which, however, gradually gives place to the normal rock. From the tunnel, drives have been carried 103 feet north and 80 feet south respectively. The reef averages about 12 inches in thickness, and in the southern drive proved to be very large in places. The quartz of the reef is of a characteristic white colour, and carries a certain amount of gold on the casing. The tunnel has been carried 62 feet eastward beyond the reef, and ends in a small laminated quartz vein dipping to the westward at an angle of 70 degrees. An underlay shaft 95 feet in depth has been sunk at a spot indicated on the geological map, Plate XVI., and connects with the drive to the north of the tunnel. A considerable amount of stoping has been done on the reef, so far as may be judged by the present condition of the workings. Very rich specimen stone is said to have been of frequent occurrence in the mine. A tramway had been laid from the tip at the mouth of the tunnel to the battery.

To the west of this lease, and between it and the alluvial flat on the main creek, are five quartz reefs, upon which, judging from the condition of the surface, a fair amount of prospecting work must have been done; there is, however, no information as to the results of this.

WESTERN SHAW No. 1 SOUTH, G.M.L. 290.—The centre of this lease is traversed by a persistent vein of laminated quartz, which extends over the whole length of the leases; whilst the south-western portion is occupied by the wide alluvial flat, which has yielded such large quantities of gold in the early days of the field. The south-west angle of the ground is occupied by a well-marked quartz reef which trends north-west and dips west at a high angle. This reef abuts against the reverse fault, which traverses the adjoining lease to the south.

GENERAL GORDON No. 1 NORTH, G.M.L. 428.—A small 6-acre lease adjoining the one previously described on the south. The important structural feature of this lease is the reverse fault, which traverses its whole extent in the position indicated upon the geological map, Plate XVI. The quartz reef, which enters the property on the north at a point about 130 feet from the north-western angle, turns sharply southwards on approaching the fault, against which it is abruptly truncated. A tunnel has been put in for a total distance of 72 feet, on the following bearings: 210 degrees, 48 feet, and 245 degrees, 24 feet; 31 feet from the mouth of the tunnel the reef was met with, but disappears a few feet at the fault. The late Mr. Inspector Becher, who sampled the reef, stated in his official report that it did not yield good prospects. An excellent view of this reverse fault, and the curving of the foliation (? bedding) planes in its proximity is to be obtained from

the rising ground to the east of the creek, on the eastern boundary of the lease.

GENERAL GORDON, G.M.L. 230.—This 12-acre lease adjoins that last described. The centre of it is traversed by the laminated quartz, with which are associated a few irregular veins of quartz. The original prospectors are stated to have obtained some good coarse gold from the outcrop of one of these veins outcropping on the steep slopes of the hillside. On the summit of the hill and to the east of the belt of the laminated quartz, a very small rich patch of alluvial (residual) gold was met with. The patch was only a few feet square, and occurred in close proximity to one of the thin irregular quartz veins, to the disintegration of which the origin of the gold is to be ascribed. A shaft has been sunk to a depth of 44 feet on a vertical quartz reef, and a crosscut driven 21 feet west, but these were inaccessible. A tunnel has been driven into the side of the hill for a distance of about 160 feet at a point some distance to the south of the shaft described, but it also was inaccessible; it is, however, asserted to have been driven to no purpose.

WESTERN SHAW CONSOLIDATED, G.M.L. 215.—This is a 12-acre lease, which adjoins the General Gordon on its southern boundary; the property is traversed throughout its whole length by the belt of laminated quartz which forms the summit of the ridge upon which the property is situated.

Near the northern boundary of the lease, at a point shown upon the geological sketch map, Plate XVI., is a quartz reef of from 6 to 8 inches in thickness; this, which underlays east at an angle of 47 degrees, has been opened out to a depth of about 12 feet. The quartz, which is of the characteristic white colour, gradually diminishes in thickness from the surface to the bottom of the shaft, at which point it is abruptly cut off by a strike fault.

The main reef, which has been opened out in the adjoining lease to the south, traverses the southern portion of the property for a distance of about 300 feet north of the southern boundary, at which point it appears to peter out on the surface. This main reef has been worked by means of two shafts and a tunnel, put in along the boundary of the two leases, in an easterly direction, near the base of the hill on the western fall of the ridge upon which the reef outcrops. The tunnel, which intersects the reef at 58 feet from its mouth, shows the following section: Schist, 27 feet; laminated quartz, 16 feet; and schist, 15 feet. The main reef at the tunnel is 6 inches in thickness; it has been exploited by a drive which has been carried north along the reef for a distance of 300 feet. The reef, wherever seen, averages about 18 inches, although in isolated places it attains a thickness of over 4 feet. At a point distant 164 feet north from the face of the tunnel, a shaft 60 feet in depth, sunk on the reef the whole way, connects with the surface; whilst a second shaft of 75 feet intersects the drive at 260 feet from the tunnel. In this shaft a level has been

driven on the reef 83 feet north from a point 40 feet below the mouth of the shaft, but such was inaccessible to me.

At a point near the western boundary of the lease, and about 440 feet from the northern boundary, is a tunnel, which has been driven westward and connects with a shallow vertical shaft adjoining the old tram-line. The workings, however, were inaccessible to me.

WESTERN SHAW EXTENDED, G.M.L. 213.—This 12-acre lease is the most southerly of the group owned by the Imperial W.A. Corporation Co., Ltd. The surface of the lease is occupied by greenstones and their cleaved and foliated derivatives. The centre of the property is traversed from end to end with the laminated quartz, which forms the main axis of Western Shaw. It dips west at an angle of 75 degrees. The main reef enters the property on the northern boundary, and can be followed southwards for a distance of 900 feet, the southern end of it being represented by a mere thread of quartz. The reef has been opened from the tunnel alluded to in the description of the adjoining lease on the north. From the face of the tunnel a drive had been carried south for a distance stated to be 300 feet. This was, however, inaccessible to me for a distance of 253 feet. An air-shaft 30 feet in depth connects with the surface at a point 30 feet south from the face of the tunnel, and a second, 70 feet in depth, at 153 feet from the same spot. The reef is showing for the whole length of the drive, and, although it varies greatly in thickness, it may be said to average about 18 inches. The quartz of which the reef is made up is almost pure white; it carries a little iron pyrites, galena, and more or less coarse gold. The original prospectors of the reef are stated to have obtained very good specimen stone along the outcrop, which may be held accountable for the amount of surface work done upon it. A large quantity of quartz obtained from the reef is lying at the mouth of the tunnel, and was not put through the battery by the owners of the property.

The following table gives the yield of the Imperial West Australian Corporation's property, so far as can be deduced from official data :—

*Table showing the Yield of the Imperial West Australian Corporation, Ltd., G.M.Ls.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Prior to 1897 . . . . .	18·50	19·00	1·02
1897 <sup>1</sup> . . . . .	1,190·50	1,060·89	·89
1898 . . . . .	12·00	34 65	2·89
1900 . . . . .	...	2 31·75	
Total . . . . .	1,221·00	1,114·54 2 31·75	·91

<sup>1</sup> For detailed returns for this year, see next page.

<sup>2</sup> From tailings.



The issues of the *Northern Public Opinion* of January 16th, February 20th, and June 5th of 1897, give the following detailed returns for that year:—

Month.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
January . . . .	140·00	522·00	3·72
February . . . .	80·00	253·00	3·16
June . . . .	240·00	474·00	1·97
Total . . . .	460·00	1,249·25	2·71

### GENERAL

So far as can be ascertained from the official figures, the following table gives the gold yield of this centre, other than that derived from the alluvium, of which there does not appear to have been any separate record, such alluvial gold as has been obtained having probably been included under the general yield of the whole of the district as defined by the authorities.

#### *Synoptical Table of the Gold Yield of the Western Shaw Reefs.*

Name of Reef.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Imperial Leases . . . .	1,221·00	1,146·29	·91
Trafalgar . . . .	30·00	90·00	3·00
Total . . . .	1,251·00	1,236·29	·98

There is very little firewood within the vicinity of the mines; whilst timber for mining and building purposes would have to be carted at least 20 miles. There is no battery for crushing the stone which might be raised from any of the reefs.

### O.—North Shaw

(With a Map, Fig. 52.)

No opportunity of visiting North Shaw presented itself, but in order that this and the two previous reports may contain information respecting every locality where mining operations are being or have been carried out, the following unpublished description by the late Mr. S. J. Becher, at one time Inspector of Mines for the district, are included.

So far as can be ascertained, the total gold yield in fine ounces of this centre has been, up to the close of 1905, as follows:—

Alluvial . . . . .	7.53 ozs.
Dollied . . . . .	567.06 „
In addition to 674.72 ozs., the result of the milling of 351.45 tons of ore.	

“The North Shaw district lies to the south-west of Marble Bar, 36 miles by horse track or 40 miles by road. The workings lie to the south of the Callina Creek about 2 miles from the junction of Callina Creek and Shaw River.

“Low hills and an extensive flat contain the reefs now being worked; most of the reefs only show their line of outcrop here and there, the main exception being the Leviathan line, which is a big white quartz reef outcropping boldly for a couple of miles.

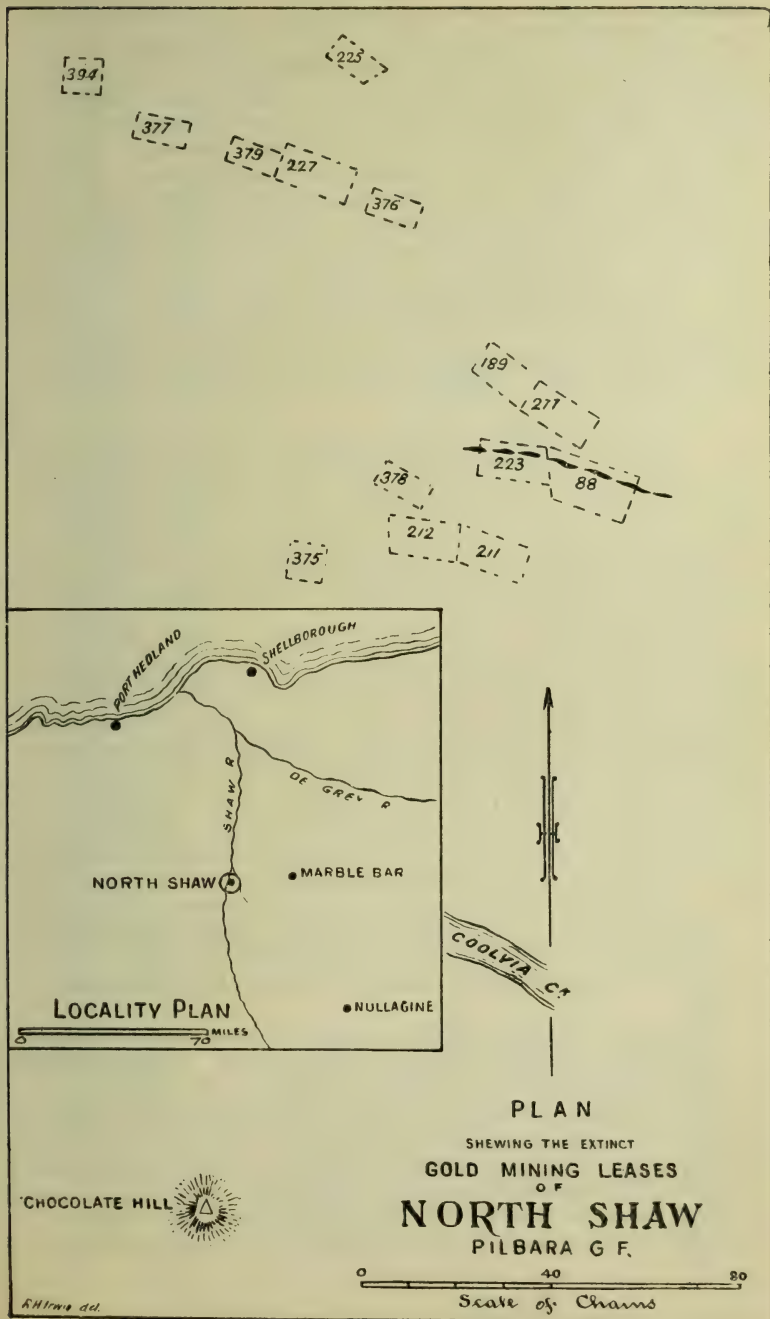
“There is an abundant supply of good timber, and several permanent pools and soaks in the river beds. A Government Well has been sunk on the flat near the Callina Lease. The country is kindly. The reefs mostly carry a lot of mineral (copper, iron, and some galena and silver ores). In the old Leviathan very coarse gold has been obtained, but most of the gold in the mineralised quartz is of a fine nature.

#### THE MINES.

“ELDORADO, G.M.L. 88.—Situated about three-quarters of a mile from Government Well. This is the oldest mine of the place, having been worked for over two years by various parties. The line of reef does not outcrop consistently, only showing here and there on this and the adjoining (west) lease. Upon this lease it is bigger than elsewhere, being in places quite 6 or 7 feet wide. The stone is mineralised with iron, copper, and silver ores, and the quality of the gold is low in value. Some handsome specimens have been obtained, and a trial crushing of 4 tons gave a return of 7 ozs. per ton. A considerable amount of work has been done, but the property became liable to forfeiture owing to the non-compliance with the labour covenants by the Eldorado G.M. Co. of Melbourne. The reef is practically vertical, with perhaps the least underlay south, the course being east and west. A vertical shaft has been sunk 60 feet and levels driven at 30 feet and 60 feet. There is now 25 feet of water in the shaft; was therefore unable to examine lower level. At the 30 feet level, in a short drive of 18 feet west, the reef apparently pinches out but should make again. Eastward a drive of 40 feet connects with No. 2 shaft, a big body of stone being driven on. The drive is carried on eastward some 30 feet on the reef. Some tons of stone at grass. Should the forfeiture be approved, a battery will at once be erected.

“ELDORADO WEST, G.M.L. 223.—Royer, Quinn, and Haste; 12 acres. Two men; partial exemption. Situated west and ad-

FIG. 52.





joining the Eldorado (late). The reef is smaller than in the Eldorado, but yields good stone all through. It retains its steepness and mineralised character. Some of the stone carrying iodargyrite and proustite shows beautiful free gold. Native silver has also been found in this line of reef. The eastern shaft is 33 feet in depth and a drive is being put in westwards towards No. 1 shaft. The reef averages 2 feet in width with good walls. No. 1, the western shaft, about 50 feet away, is down 40 feet. A short drive of 12 feet has been made eastwards at the 33 feet level to connect with drive from No. 2 shaft. A short drive has also been made west. About 100 tons at grass awaiting crushing. Upon the hillside (south) above the main line of reef, 2 other parallel lines of reef have been prospected superficially, yielding encouraging prospects. These reefs apparently underlay north at an angle of about 60 degrees, and should therefore meet the main line in depth. The country is diorite or metamorphic schist on both walls.

“THE BERTHA, G.M.L. 431, 12 acres (W. McPhee).—A newly taken up lease, situated adjoining Eldorado. The reef, which is apparently of considerable width, is a cross line to the Eldorado line of reef, having a north and south course and underlaying east. The stone exposed in a 10-foot hole on the underlay is of encouraging character, and is mineralised with lead and iron ores. In washing dish prospects, carbonate of lead remains as a fine residue occasionally.

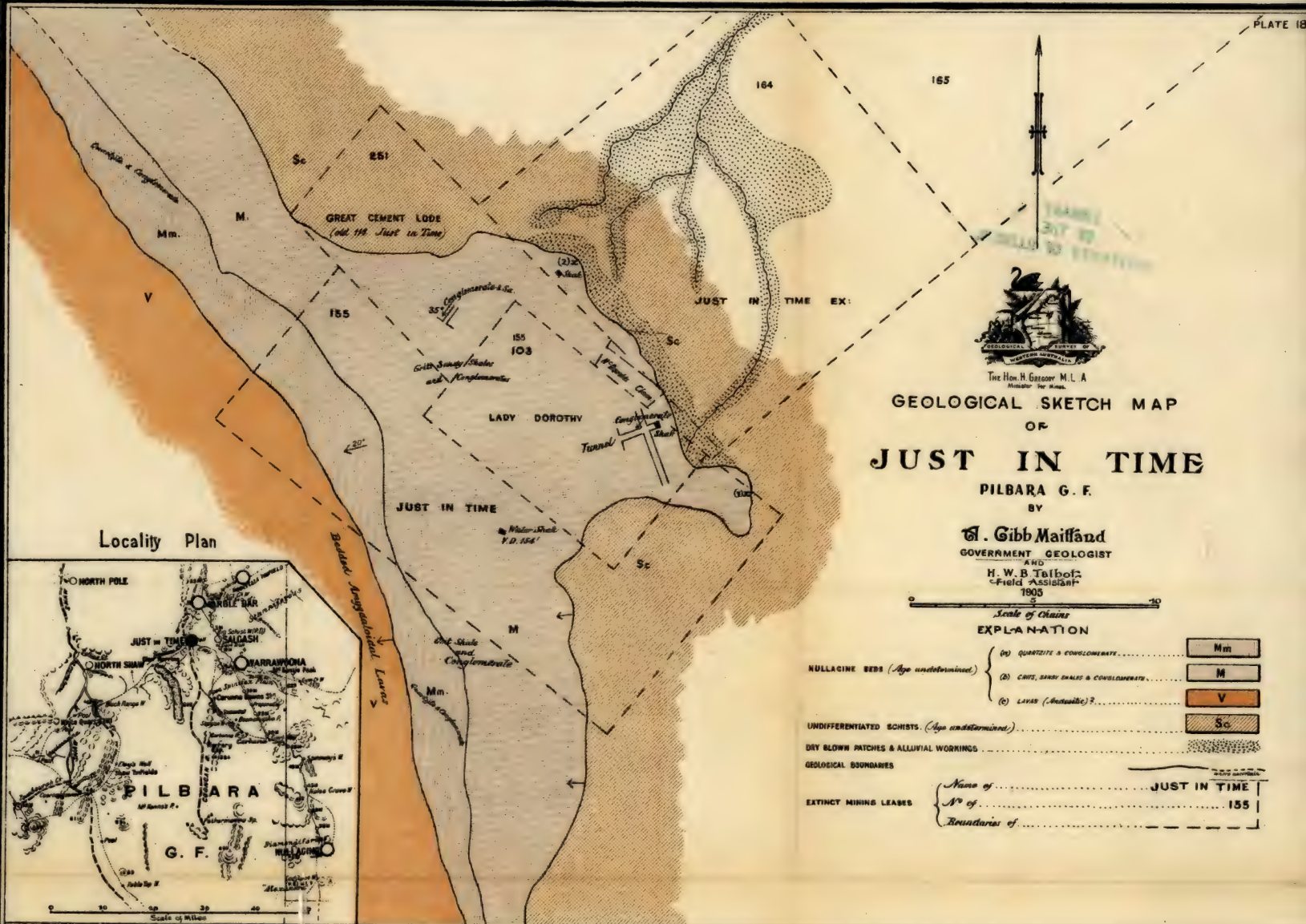
“AURARIA, G.M.L. 394, 6 acres (Wm. Wye).—Situated on the plain about three-quarters of a mile west of the Government Well, half a mile from Callina Creek, and  $1\frac{1}{2}$  miles from junction of Callina Creek and Shaw River. The reef outcrops only here and there, but the line is marked. Prospecting trenches have been sunk exposing a well-defined reef of 12 inches to 2 feet. A shaft is down 46 feet on the underlay, the reef having an east and west course and underlaying north at an angle of 65 degrees. The walls are true and consist of an altered slate hanging wall country with porphyritic intrusions and a metamorphic schist footwall country, very hard. The shaft is well propped and has good ladders. The stone is mineralised with iron and a little copper. Average sample from ore stack gave  $1\frac{1}{2}$  ounces prospect. About 20 tons at grass. Stone from reef exposed in prospecting trenches gives prospects of about 1 ounce.

“STRUCK OIL, G.M.L. 375, 6 acres (W. Wye).—Situate about three-quarters of a mile south-west of Eldorado. Course of reef (inconsistent) east and west, underlay slightly south. Shaft (vertical) sunk 30 feet. At 15 feet level reef cut right off horizontally, apparently faulted across from south side. Short crosscut shaft failed to pick up. At bottom level, drive 13 feet, but no reef. Stone highly mineralised and prospecting well; trenched in other places. Consider it to be only a superficial small gash vein.

“NIL DESPERANDUM, G.M.L. 378, 6 acres (Wye and Walker).—







S.W.

# GEOLOGICAL SECTION ACROSS JUST IN TIME

N.E.





Situated due west of Eldorado West, about half a mile distant. A small very highly mineralised (copper) reef of about 8 inches to 18 inches outcrops flatly around the base of low hill; probable course east and west, and underlay north. A general sample yielding 2 ozs. prospect. A little trenching done. Another parallel reef outcrops on hillside; similar stone. Shaft (underlay) just commenced where stone is about 12 inches to 18 inches in thickness. Good prospect.

"GENERAL.—A boldly-marked line of reef some 2 feet to 12 feet in thickness, and extending for a couple of miles, lies parallel to and south of the Eldorado. It is known as the Leviathan, from the name of two abandoned leases taken up formerly on the west end, where a rich patch of some 500 ozs. of gold or more was worked out, and where, around the reef, some rich alluvial had been obtained. The reef is mostly of very fine quartz. A small shaft was put down on the old Leviathan lease area, but nothing is now being done on this line of reef."

### P.—Just-in-Time

(With a Geological Sketch Map, Plate XVIII.)

The mining centre of Just-in-Time, which was the scene of a great rush in 1892, is situated about 8 miles south of Marble Bar, on one of the Tributaries of the Coongan River; its position in relation to the other mining centres is indicated on the geological sketch map of the Pilbara Goldfield, which forms the frontispiece to this report.

Although the gold yield of Just-in-Time has been small, considerable interest attaches to the locality on account of the resemblance of its auriferous deposits to the gold-bearing conglomerates of Nullagine, which have been fully described in a former report.<sup>1</sup>

### GENERAL GEOLOGICAL FEATURES

The locality upon which operations have been principally centred is upon the slopes and summits of a relatively narrow and conspicuous ridge which trends generally north-west and south-east.

In its general features there are two distinct geological formations (in addition to the recent superficial accumulations) in the district, viz.:—

- (a) An older series of schists and allied rocks, and
- (b) A series of grits, quartzites, sandy shales, and conglomerate, together with bedded lavas, the whole being the equivalent of the Nullagine Series, which is so extensively developed in the north-west division of the State.

<sup>1</sup> Geol. Surv., Bulletin 20. Perth: By Authority, 1905, pp. 12-52.

The schists and allied rocks form part of the zone which embraces Yandicoogina, Warrawoona, Marble Bar, and Talga Talga, which have been fully described in former reports.<sup>1</sup> The schists as developed in the vicinity of Just-in-Time were not examined in any detail; they were found, as was the case elsewhere in the district, to carry quartz reefs, which, however, did not appear to be of any great extent.

Approaching Just-in-Time from the south-west, by way of Cooglegong, a complete section of the Nullagine Series is obtained. The beds in this locality cover a width of about 21 miles on the surface.

After leaving the granite, which forms the staple formation from Cooglegong to the Black Range Well (geological sketch map of Pilbara—Frontispiece), a coarse conglomerate or boulder bed makes its appearance in the bed of the river at the crossing. The conglomerate contains large boulders of granite of the Cooglegong type. From the Black Range Well the road to Just-in-Time trends generally north-east, and traverses grits, &c., with occasional relatively small patches of granite and schists, which the irregularity of the floor upon which the Nullagine Beds were laid down causes to rise to the present surface of the ground and protrude through the newer beds. Some distance from the old Black Range Well, and a little distance from the new well, which had recently been sunk, and the position of which is not indicated upon any of the published plans, the sedimentary rocks give place to vesicular lavas, &c., of the type common to the series elsewhere. At Glen Herring, a very coarse conglomerate and quartzite, dipping at 45 degrees to the north-east, makes its appearance in the lofty ranges which abound in the vicinity. The conglomerate at the base is made up of pebbles and boulders of the jaspideous quartzite which forms the picturesque band of rock at Marble Bar.<sup>2</sup>

In the Gorge at Glen Herring the conglomerate was seen to be overlaid by lavas, &c., which were faulted against the quartzite as shown in Fig. 53.

As careful an examination of the Glen Herring section as the short time at my disposal admitted, suggested the possibility of the conglomerate being the base of the Warrawoona Beds, though it must be admitted that there is little either for or against that view. From Glen Herring to Just-in-Time, the whole country in the vicinity of the route is occupied by the lavas and associated sedimentary rocks of the Nullagine Series.

At Just-in-Time itself, as may be seen by an inspection of the geological section (which is upon the same scale as the map), the Nullagine Series is represented by about 350 feet of grits, quartzites, sandy shales, and conglomerate, together with a great thickness of bedded lavas. At the base of the series, and resting upon the older

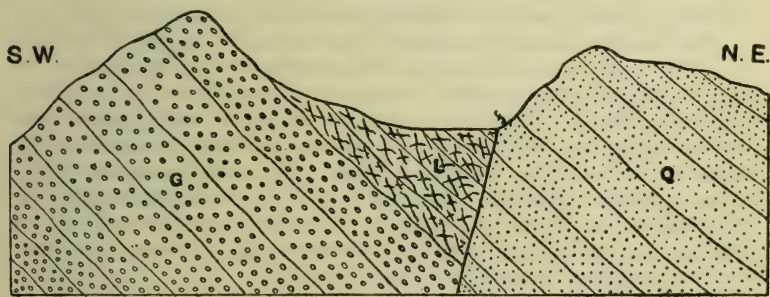
<sup>1</sup> Geol. Surv., Bulletin 15. Perth: By Authority, 1904, pp. 44–51, 61–72; and Geol. Surv., Bulletin 20. Perth: By Authority, 1905, pp. 57–105, 105–120.

<sup>2</sup> Geol. Surv., Bulletin 20. Perth: By Authority, 1905, p. 107.

rocks, is a very ferruginous conglomerate [6496] which varies from an inch up to 5 feet 6 inches in thickness.

In many respects the auriferous conglomerate resembles the ferruginous bands which form such an important feature in the series as developed at Nullagine itself. The conglomerate consists mainly of boulders and rounded and subangular fragments of the neighbouring underlying rocks, together with occasional pebbles of a pre-existing conglomerate. The matrix of the conglomerate is very hard and siliceous, due to the deposition of secondary silica, &c. Certain portions of the conglomerate [6496] contain a sufficient quantity of hematite and limonite, in the form of the cube, the octahedron, and the dodecahedron, to give a distinctive character to the rock. Some of the faces of the crystals are striated in the manner common to pyrites. The iron ore is virtually confined to

FIG. 53.



Section at Glen Herring Coongan River Pilbara G.F.

G Conglomerate    Q Quartzite    L Lavas    f Fault

the thin lenticular bed at the base of the series, though a very small quantity occurs in the stratum, on a higher horizon at the mouth of the tunnel in G.M.L. 114. A portion of the very ferruginous conglomerate [6496] yielded, as the result of an assay in the Survey Laboratory, merely a trace (*i.e.* less than half a pennyweight) of gold per ton. Though a careful search was made, no free gold could be detected in any of the conglomerate at present open to examination.

The late Mr. Inspector Becher, who visited the district in 1896, when active operations were going on, makes the following important observations:—

“The lode ‘freezes’ very tightly on to the walls, and as the best gold is found near and on the footwall, a few inches of footwall is taken out with the ore in order not to miss any gold; in fact I have seen a specimen showing gold in the footwall stone taken from a few inches into it, away from the lode. . . . The



gold occurs as waterworn particles and grains sometimes attaining as much as several ounces in weight."

This latter observation is of interest and importance, in that it would seem at first sight that some at any rate of the gold in the conglomerate is of a detrital character and origin. It is of course conceivable from the nature and mode of formation of the conglomerate that a certain quantity of detrital gold may occur in it, but from the fact that many of the crystals and fragments of the iron ore occur in a more or less rounded form, I am inclined to the belief that the rounding of the gold also is due to other causes than attrition, and that it is of secondary origin. The conglomerate must have been of such a nature as would readily permit of the more or less free circulation of mineral-bearing solutions, whilst the underlying schists are practically impermeable.

The occurrence of secondary gold in the zone of decomposition of the bed rock, upon which the auriferous detrital deposits rest, has already been noted in another portion of the State.<sup>1</sup>

The auriferous conglomerate at the base of the series, however, is not of any very great horizontal extent, nor so far as can be seen in the workings does it appear to penetrate to any considerable depth. It forms in fact a lenticular bed of somewhat local occurrence, which, from its present position, was evidently deposited upon a very uneven surface. The conglomerate occurs in a local depression on the surface of the underlying rocks, for the bottom can be seen rising to considerable altitudes above the level of the bed exposed near the western angle of what is shown on the geological map as McDonald's Claim.

The creek and its tributaries, which takes its rise in the escarpment of the conglomerate and flows across what was originally G.M.L. 164, has been the scene of some vigorous prospecting. This creek is stated to have yielded a fair quantity of alluvial gold, of which unfortunately there appears to have been no separate record kept. The amount derived from this source is probably included in the returns showing the yield of the Marble Bar district as defined by the Mines Department. Most of the gold from this source owed its origin to the disintegration of the conglomerate itself.

The sedimentary beds of Just-in-Time are covered, as may be seen by the geological sketch map and section, by a considerable thickness of andesitic (?) lavas [6498, 6499], many beds of which are vesicular and amygdaloidal. In their general character and behaviour, they agree very closely with those which are exposed in the river for some miles above the township of Nullagine.<sup>2</sup>

No volcanic focus from which these lavas emanated was noticed within the small area examined. The beds, however, cover a very wide extent of country in the vicinity of Just-in-Time, and it is

<sup>1</sup> Annual Progress Report of the Geological Survey for the Year 1899. Perth: By Authority, 1900, pp. 9 and 43.

<sup>2</sup> Geol. Surv., Bulletin 20. Perth: By Authority, 1905, pp. 23, 24 and 26, 27.

quite possible that much more detailed search than has at present been carried out would lead to the discovery of the source from which these beds were derived.

### THE MINES.

No work of any description was being carried on at the date of my visit, and operations had evidently ceased some years ago; nevertheless all the accessible workings were visited and carefully inspected. For descriptive purposes it is convenient to deal with the various workings within the boundaries of the leases existing at the date operations were in full swing; the positions of these are shown upon the geological map, Plate XVIII.

It may be noticed that the nomenclature of the properties leaves very much to be desired in that two distinct leases have been registered under one name, a condition of affairs which is confusing and apt to mislead. A similarity in nomenclature in the case of certain leases at Nullagine has been previously noticed.<sup>1</sup>

**JUST-IN-TIME, G.M.L. 114** (later on, **The Great Cement Lode, G.M.L. 251**).—This 6-acre lease was applied for by Messrs. Dunsford and Hogan in 1894. The northern half of the property is occupied by the older crystalline rocks, and the remainder by the sedimentary beds of the Nullagine Series.

The only work done upon the property appears to have been a tunnel driven 48 feet on a bearing of 41 degrees, in that portion of the lease indicated on the map. The tunnel itself has been carried through grit, which dips at an angle of about 35 degrees in a direction of south 50 degrees west. At the mouth of the tunnel is a bed of conglomerate [6497] about 2 feet in thickness, of a somewhat similar type to that which forms the base of the series in G.M.L. 165, but not nearly so ferruginous.

**JUST-IN-TIME, G.M.L. 155** (includes **Lady Dorothy, G.M.L. 103**).—This 21-acre lease, which includes the G.M.L. 103 (known as the **Lady Dorothy**), was applied for in January 1895, and a considerable amount of work had evidently been done upon it. The old 6-acre lease the **Lady Dorothy** was applied for by Messrs. Banger and Church in 1894, and was eventually merged into the larger one.

A tunnel 79 feet in length has been driven on a bearing of north 60 degrees east for a distance of 79 feet to the foot of an underlay shaft, 26 feet in length, which connects with a vertical one 20 feet in depth, Fig. 54. The section in the tunnel comprises a bed of conglomerate and grit, which is overlaid by a bed of fine sandy shale, which occupies about 20 feet of the tunnel, starting from the centre of the drive at the face. From the face of the tunnel, a drive has been put in along the conglomerate for a distance of 136 feet. At the face of the drive, the old floor of the

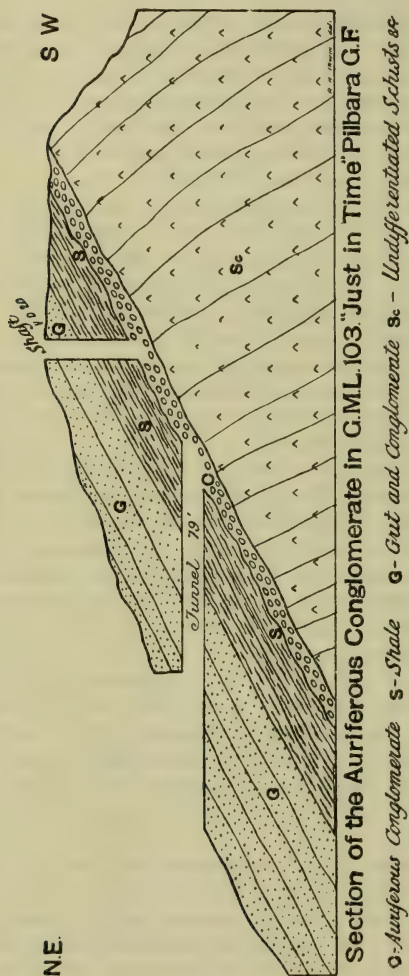
<sup>1</sup> Geol. Surv. Bulletin, 20. Perth: By Authority, 1905, pp. 38 and 39.

underlying crystalline rocks has risen to the roof of the drive and exposes barely an inch of fine conglomerate or grit. The maximum thickness of the basal auriferous conglomerate in the drive is 5 feet 6 inches. Twenty feet from the mouth of the tunnel in this drive a winze has been sunk for a distance of 48 feet on the conglomerate,

which dips at an angle of from 20 to 25 degrees; at the bottom of the winze is about 5 feet of a boulder conglomerate, many of the boulders being from 12 to 18 inches in diameter. A drive has been put in north-west from the face of the tunnel, but it proved to be absolutely inaccessible. Between the drive at this level and the surface, there is an intermediate one of considerable length, but it proved to be inaccessible, unless at some considerable personal risk.

At a point (1) on the map an attempt has been made to open out the conglomerate, the base of which is a somewhat higher level than that at the main shaft. The section where prospecting operations had been commenced showed the following: Conglomerate, 20 feet; sandy shale, 5 feet 2 inches; ferruginous conglomerate [6496], 2 feet 4 inches; the whole resting upon the older crystalline rocks. A sample of this on assay in the official laboratory proved to be appreciably auriferous.

FIG. 54.



A main water shaft had been carried down to a depth of 154 feet, and judging by the material lying in the dump, bed rock must have been reached. This well, which is stated to have cost £1000, yielded good water, but not in sufficient quantity for battery purposes. There are unfortunately no data available which indicates



the depth at which the base of the sedimentary series was met with in the water shaft.

**JUST-IN-TIME EXTENDED, G.M.L. 164.**—This 20-acre lease was applied for by Mr. J. A. S. Roe in 1895; this area comprised the old alluvial ground, upon which a good deal of work has been done, and which it was at one time intended to sluice. The lease, however, became void in December 1897.

A fair amount of prospecting work has been done at different points on the face of the escarpment of the conglomerate, which sweeps round the face of the hill.

At a point (2) on the map the conglomerate, which was 4 feet thick, was worked from the surface to the vertical shaft, which is stated to have cut the bed at 35 feet from the surface. From the foot of the vertical shaft, the conglomerate is stated to have been followed down on the dip for a distance of 40 feet, and a good deal of it stoped out. These workings, however, were inaccessible.

The conglomerate is overlaid by a fine-grained and drab-coloured sandstone or sandy shale, which was also intersected in the vertical shaft.

### GENERAL

The following table shows the yield of the auriferous conglomerate, so far as such can be obtained from the returns of crushings furnished to the Government :—

*Table showing the Yield of Auriferous Conglomerate from the Just-in-Time G.Ms., Ltd., G.M.Ls. 155, 164/5.*

Year.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Prior to 1897 . . . .	30·00	45·00	1·50
1897 . . . . .	25·00	1·40	·05
1898 . . . . .	5·00	·90	·18
Total . . . . .	60·00	47·30	·78

There is unfortunately no separate record of the gold which has been obtained from the "alluvial ground" on the face of the escarpment.

The occurrence of an auriferous conglomerate, in the same stratigraphical series, at least 50 miles distant from Nullagine where identical geological conditions prevail, would seem to encourage efforts in the direction of carefully prospecting other portions of the basal members of the series, which occupy such an extensive area in the north-west district.

**Q.—The Wodgina Tinfield**

*(With a Geological Sketch Map, Plate XIX.)*

The Wodgina Tinfield is situated on the headwaters of the western branch of the Turner River, and within the limits of the Pilbara Goldfield as defined by the authorities, about 74 miles from Port Hedland, and 15 miles due east of the Yule River, which marks the boundary between the Pilbara and West Pilbara Goldfields.

Tin appears to have been first officially recorded from this field by the Warden during the year 1902. Since that date stimulus has been given to prospecting in the vicinity, and during 1905 considerable activity manifested itself at Wodgina in the number of mining leases which had been pegged out. An important find of tantalum at Wodgina resulted in a considerable influx of population, but the excitement which this find made rapidly abated with the heavy fall in the market value of the metal.

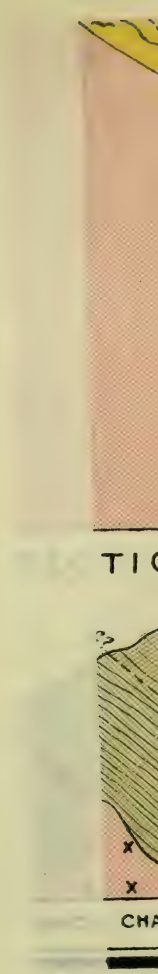
In addition to the discoveries at Wodgina proper, three leases have been worked at what is known as the Stannum, about 8 or 9 miles to the south, upon the same range. This little group has, according to the official figures, produced 6·20 tons of tin during the short period which has elapsed since its discovery.

The total output from the whole of the Wodgina district has, according to the figures available up to the close of the year 1905, been 31·45 tons of tin valued at £2462, and of tantalite 70·95 tons of the estimated value of £8925. There are good reasons for the belief that the tin yield disclosed by these figures does not represent the total yield of Wodgina, for tin buyers apparently only commenced reporting their purchases towards the close of 1905.

**GENERAL GEOLOGICAL FEATURES**

Geologically the district consists of a series of metamorphosed, sedimentary, and igneous rocks, the age of which has not been determined. These rocks skirt a very extensive granite mass, which, as may be seen by an inspection of the geological sketch map (frontispiece), occupies a very large area of country.

These bedded rocks are very much folded and faulted, and upon the whole have a prevailing dip to the west; they occupy a very rugged range, which rises to considerable altitudes above the level of the surrounding plains. These rocks are pierced by granite and pegmatite veins (offshoots from the mass previously described) which invariably occur in intimate connection with the tin and tantalum ores. The occurrence of these pegmatite veins is of considerable economic importance, because all the known lode tin deposits occur in association with them. These veins have been mapped in some detail both at Wodgina and Stannum. The geological maps of these two centres should afford a valuable guide to those engaged in mining operations on the field.









Whatever may be the geological age of the main mass of the strata exposed at Wodgina, the intrusive granite is of decidedly later date than the folding, &c., which the bedded rocks have undergone, for neither the granite nor its offshoots have suffered any dynamical alteration since their injection.

So far as has at present been observed, what may be called the tin belt of Wodgina is limited to the area occupied by the granitic veins; though, of course, the mode of occurrence of the tin at Moolyella<sup>1</sup> and Cooglegong in the heart of the granite some miles from its edge points to the fact that the tin at Wodgina need not of necessity be confined to the relatively narrow strip which comprises the apophyses of the granite mass.

The granite region of this portion of the Pilbara Goldfield covers an area of, as may be seen by an inspection of the geological sketch map which forms the frontispiece to this report, at least 2400 square miles. The Wodgina belt proper extends, so far as observations have at present been carried, for a distance of at least 80 miles north-west and south-east, and has a width of about 30 miles.

The granite is composed of quartz, felspar, and mica, which latter is chiefly muscovite. The exact age of the granite cannot as yet be determined; it passes under the Nullagine beds, which are assumed to be of Cambrian Age, hence, such being the case, the granite must be at least pre-Cambrian.

When laid down upon a map and viewed broadly, it is noticed that these veins have a rude parallelism, generally north-east and south-west, which is coincident with that of the dominant structural features of the district. The exception is in the case of those veins which traverse the greenstones; here, where the dykes have been mapped, their general strike is north and south. In those cases in which the dykes depart markedly from what may be called the normal strike of the schists, it may be that the veins have followed old pre-existing fracture lines.

These pegmatite veins are seen to be offshoots from the main granite mass which covers such a large area of country to the east; a triangular portion of this granite occupies the south-eastern corner of the area mapped, and from this mass veins are seen to emanate. An interpretation of the general relationships of these veins to the main granite mass is shown in the geological section at the foot of the map which forms Plate XIX.

The dykes are very irregular, both in width and underlie, and some are more persistent in strike than others; they vary from mere threads to veins over 500 feet in width, whilst their underlie has neither any prevailing angle nor direction.

These veins are made up of a coarse-grained rock composed of mica, quartz, felspar, and occasionally tourmaline, and may be described as pegmatite, using the term in the sense in which it was

<sup>1</sup> Preliminary Report on the Geological Features and Mineral Resources of the Pilbara Goldfield: A. Gibb Maitland, Government Geologist. Geol. Surv., Bull. 15. Perth: By Authority, 1904, pp. 102-109.

applied by Delesse for any coarse-grained granitic rock containing mica, quartz, felspar, and tourmaline.

In the vicinity of and along the margins of many of the pegmatite dykes are bands or bunches of tourmaline; in some cases these tourmaline bands occur only on one side of the dykes, constituting as it were a marginal zone either in the dyke or in the adjacent country rock. In others the pegmatite dykes consist almost entirely of quartz, and are crowded with tourmaline, sometimes to such an extent as to make up fully one-third of the entire rock [6450].

The tin ore appears to be an original constituent of the veins; it is, however, so far as observations have at present been carried, concentrated along certain lines in these dykes, and does not appear to be generally disseminated in minute quantities in the pegmatite. The tin occurs in all shapes, from minute grains up to pieces weighing as much as 50 or 60 pounds.

The bed of the ravines and the slopes on the hillsides carry detrital and residual tin and tantalite everywhere over the whole area occupied by the pegmatite veins; and in many cases the detrital and residual tin has been traced to the pegmatite veins.

These pegmatites vary very much in their characters, even in different portions of the same vein.

The pegmatite [6478] which forms the tin lode of the Stannum mine, M.L. 79, is a coarse-grained rock, which traverses the whole length of the property, and sends off three branches indicated on the geological sketch map of the Stannum Group, Plate XX. The rock is made up of quartz, albite, an amethystine lithia mica, blue semi-transparent tourmaline, together with clear colourless topaz, which latter exhibits well-defined cleavage.

The very coarse-grained pegmatite [6466] opened out in J. C. Williams' (or Bull's) lode claim, consists of quartz, a coarsely crystallised grey felspar, orthoclase, together with about equal proportions of a fine-grained white felspar, which proved on investigation to be albite. A partial analysis of the orthoclase in the survey laboratory showed it to contain 12·80 per cent. of potash ( $K_2O$ ) and of soda ( $Na_2O$ ) 3·00 per cent.

The bluish-coloured pegmatite [6454] which forms the lode traversing the Tinstone mine, M.L. 89, is a medium-grained rock, consisting principally of quartz, lepidolite, together with orthoclase. The rock owes its colour to the presence of the mica, lepidolite.

Apart from the granite, which occupies the south-eastern corner of that portion of Wodinga which has been geologically mapped, the country is occupied by a belt of schistose rocks, some of which may have affinities with those of igneous origin [6461], together with a large development of grits, quartzites, &c., which dip at varying angles to the westward.

Above these lie a great thickness of laminated iron-bearing quartzites [6460], together with some very siliceous quartzites, with scarcely any iron [6452]. Portions of the ferruginous quartzites



are very much puckered and contorted, and even in hand specimens [6460] exhibit faulting on a very minute scale. These beds, which are associated with bands of a nondescript rock approaching very closely to very ferruginous and siliceous clay slates, have on lithological grounds been separately distinguished on the geological sketch map of the field, Plate XIX. The relation which these highly-ferruginous beds bear to those of the lower western slopes of the range is by no means clear, though there are very strong grounds for the belief that in some portions of the field the junction between the two series is marked by a line of fault.

At a point (A) on the map is a fairly conspicuous band of a quartz rock, which looks like a dyke; this continues without interruption to the north angle of M.L. 88, where it has been faulted. The same rock extends also for about 10 chains north-east from (A); on account of its making such a conspicuous feature in this portion of the field, it has been separately distinguished on the geological map.

The north-eastern portion of Wodgina is occupied by fine-grained bedded greenstone [6453], which in some places is vesicular and in others occasionally agglomeratic. The pegmatite veins which carry the tantalite occur in this greenstone area.

The general relationship of these rocks to one another is shown in the section at the foot of the geological map, Plate XIX.

A very short distance east of the Government Well No. 1, and just outside the eastern boundary of the geological map, is about 15 or 20 feet of a conglomerate of subangular quartz, which rests directly upon granite. The conglomerate is of much more recent origin than the sedimentary rocks of Wodgina. Fragments of this newer conglomerate strew the surface over a considerable area, showing that the formation must have been more extensive than at present obtains. It is possible that this conglomerate is an outlier of the Nullagine Series, which occurs in great force in other portions of the district.

#### THE ORE DEPOSITS.

The following are full particulars regarding any of the workings, on the various ore deposits, opened up at the date of my visit to the field. For purposes of convenience, the deposits are described under the names of the respective leases.

M.L. 88, NIELSON.—This property is the most southerly of all the leases situated at Wodgina proper. It lies about a mile south-west of the Government Well, sunk on the east side of the range of hills which separates the two mining camps.

The tin lode on this ground was discovered by tracing the tin found in the creek below up the side of the hill to the site of the present workings.

By far the larger portion of the property is included within what may be called the tableland, at a considerable elevation above the general level of the surrounding country. The ground is

occupied by quartzites, mica, and hornblende slates, in addition to the iron-bearing quartzites (?), which latter cover fully three-quarters of the surface.

The only workings on the ground are situated near the northern boundary, and high up on the eastern face of the range. Operations have been confined to a thin sigmoid-shaped pegmatite dyke, which is traversed by two, apparently vertical, faults having a general strike of north-east and south-west.

The westernmost working is an opencut, exposing a total thickness of 8 feet of rock, containing a band of quartz (pegmatitic) 3 feet in thickness, associated with from 12 to 18 inches of a yellow clayey rock, which in all probability represents the aluminous portion of the pegmatite. This rock (the lode) has been faulted against the iron-bearing quartzite (?) on the west. So far as can be seen in the present condition of the workings, the quartz vein appears to underlie southwards at a very low angle.

The band upon which prospecting operations were being carried out can be followed round the face of the hill to the eastern workings, which are 142 feet distant. At one spot between the two workings the quartz vein has increased in thickness to 10 feet, but diminishes rapidly to the east. In the eastern workings the decomposed clayey rock (pegmatite) is about 5 feet in thickness and exposes coarse angular tin [6451]. A very good pocket of ore is said to have been obtained from these workings, and, from what was pointed out to me, it appears that the rich ore pockets seem almost invariably to have occurred near those spots where the lode is intersected by the faults.

From the eastern workings the dyke (the "lode") can be followed for some distance round the hill in the direction of and to the point shown upon the plan, Plate XIX. The dyke intersects a vein of quartz, which can be followed across country for a considerable distance to the north-east; this is of some importance, in that it shows that prior to the formation of the tin-bearing veins other reefs had not only been formed but faulted.

M.L. 89, TINSTONE, Hazelwood.—The ground embraced within the boundaries of this lease lies near to and adjoins the south-west angle of the Cassiterite, M.L. 84.

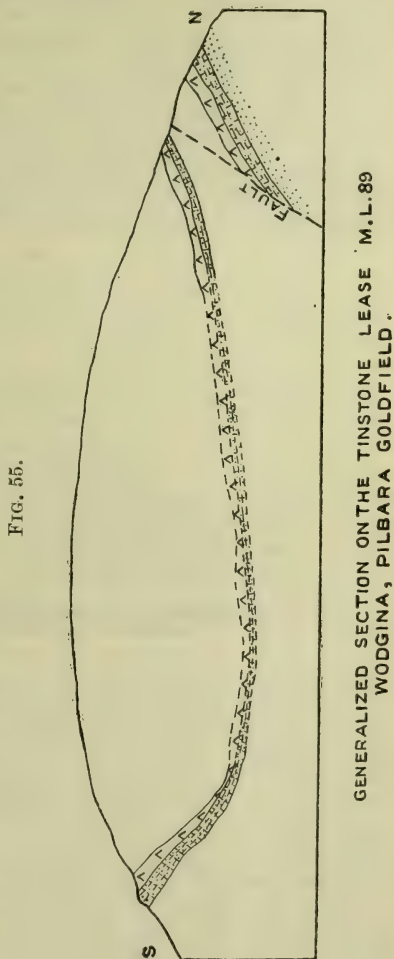
The property lies in the heart of the main range, and is drained by the two important tributaries of the Two-mile Creek, the head waters of the northern branch, a steep-sided ravine having been worked in a more or less desultory fashion for the detrital tin it contains. The surface of the lease is occupied by the iron-bearing quartzites (?) which everywhere make up the staple formation of range. These bedded rocks are intersected by six distinct pegmatite veins, the positions of which have been laid down with a considerable degree of accuracy upon the geological map. In three cases the underlie of the veins could be distinctly made out, and in two of them the amount accurately measured; these data have also been indicated on the map.

In the north and south pegmatite vein which enters the lease from the eastern boundary of M.L. 85, the Commonwealth, is a quartz [6454] of a cobalt blue colour, containing what appears to be small crystals of felspar.

The most southerly working on the property is an open cut near the western extremity of the kylie (boomerang) shaped pegmatite, which underlies at 35 degrees to the northward. This open cut exposes a thin vein of tourmaline rock [6454] underlying at the surface at an angle of 35 degrees to the north, 40 degrees west, though at the bottom the vein dips at a slightly steeper angle, 45 degrees, but in the same direction. This vein is of a dull leaden grey colour, and contains tourmaline and mica in much smaller quantity, together with a little tin. It forms the foot-wall of a decomposed pegmatite vein of about 2 feet in thickness, and rests directly upon quartzite of the prevailing type. This dyke can be followed round the slope of the hill to a point almost directly above the mouth of the main tunnel.

This tunnel has been driven for a distance of 64 feet in a general direction of south 30 degrees west along the feather edge of a pegmatite dyke, which, near the mouth, is 2 feet 6 inches in width and with a high underlay to the east. Sections in the tunnel show the dyke to be faulted, and in all probability it is separated from that last described by a fault, as shown in the Fig. 55. Both walls of the dyke are highly micaceous and contain tourmaline; whilst the feldspars of the pegmatite are very rapidly decomposing in the direction of kaolin. A few feet farther west is an open cut along the outcrop of the vein worked in the tunnel; it contains coarse angular tin and tourmaline.

Fig. 55 shows the relation of the different veins to one another.

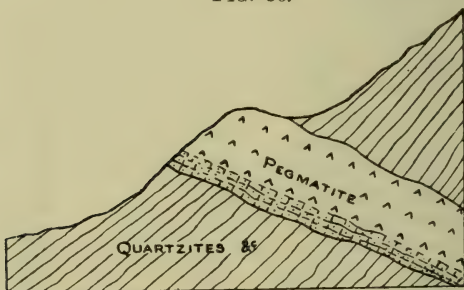




M.L. 91, WODGINA STAR.—This property adjoins the Cassiterite lease on its north-east corner, and on the eastern slopes of the high ground which forms the main axis of the tinfield. The surface is drained by the upper portions of three creeks which fall into the tributaries of the Turner River. The northernmost creek has been more or less extensively worked along its whole course. A large portion of the surface is occupied by pegmatitic veins, the position and extent of which are indicated upon the geological sketch map, Plate XIX.

The only work other than that in the creek done upon the ground is the sinking of a shallow prospecting shaft near the head of the northern creek, close to the boundary of the Cassiterite lease. This shaft had, at the date of my visit, been carried down to a vertical depth of 20 feet, through the normal country rock of the field, which in the shaft was found to be dipping at

FIG. 56.



SECTION ON THE COMMONWEALTH LEASE M.L.85  
WODGINA, PILBARA GOLDFIELD.

an angle of 60 degrees to the north-east. The shaft, as may be seen by an inspection of the map, is just upon the north side of a thin pegmatite vein, which extends from the adjoining lease on the west. The detrital tin in the gully below the shaft in all probability owes its origin to the disintegration of the dyke previously mentioned, and possibly in part to the one more immediately adjoining it on the north. No other work has been done upon the lease beyond that described.

M.L. 85, COMMONWEALTH.—This lease adjoins the Cassiterite on the south. The larger portion of the surface is occupied with the quartzites, and a small triangular patch of greenstone occupies the north-west angle of the lease. The quartzites, &c., are traversed by granitic and pegmatitic veins, the relative positions of which are indicated on the geological sketch map. The only work done on this lease consists of an open cut 25 feet long, put in along the face of a pegmatite dyke, 6 feet thick, which underlies at a low angle to the west. The under surface of the dyke

(Fig. 56) contains a foot or two of a micaceous and tourmaline rock [6464] carrying tin of the ordinary type. Many large crystals of tin may be seen in the rock.

M.L. 84, CASSITERITE.—This lease is the largest and earliest of any of the holdings at Wodgina. The ground was originally taken up by Messrs. A. G. McCarthy and David Ogilvie, in the year 1903, since which date it has, according to the official figures, produced 12·35 tons of tin.

The property occupies the highest portion of the range, which forms the backbone of Wodgina, and is drained by the tributaries of McCarthy's Creek, from one of which, Ogilvie's Gully, a considerable quantity of detrital tin has been obtained. Considerably more than two-thirds of the surface of the Cassiterite is occupied by flaggy quartzites and ferruginous clay slates of the type common to the district. The south-western portion of the lease is occupied by greenstones, which make up the whole of the country to the west.

An important feature in the geology of the property is the number and extent of the pegmatite veins which intersect the country rock in all directions and cover a fairly extensive area of the surface. The section which accompanies the geological map shows the relation which these dykes bear to one another.

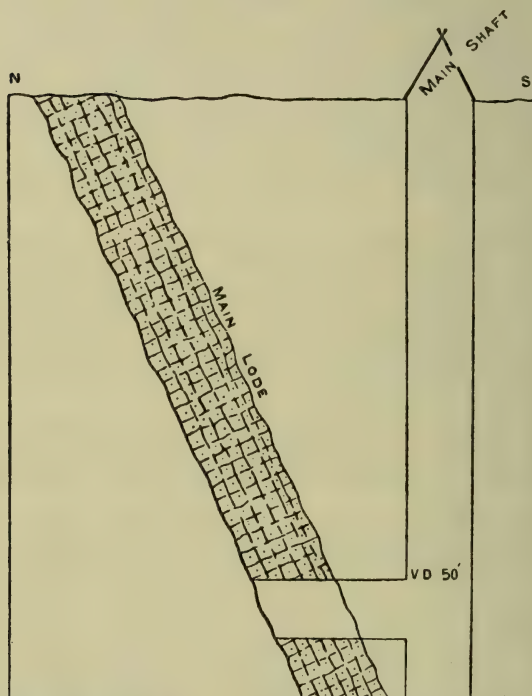
Not very much work has been done upon the lease considering the time it has been in existence.

Operations have up to the present been principally confined to what is known as the main lode, which is situated on the highest portion of the ground near the north-west angle of the lease.

The main lode extends for some distance across the surface in a north-east and south-west direction. It outcrops north-east from the northern boundary of the lease for a distance of about 100 feet, at which point it ceases to make any appearance on the surface. On the northern boundary of the lease, and just outside it, is an inaccessible vertical shaft (1) sunk to a depth of 20 feet, apparently upon the main lode; at the mouth of the shaft is a quartz reef (? pegmatite) 18 inches in thickness. The main lode, which contains coarse angular tin [6463], can be followed from the creek which crosses the northern boundary of the lease up the side of the hill in the direction of the main shaft. At 80 feet up from the creek the main lode has been opened up to a depth of 11 feet; at the surface it is 4 inches in width, but has increased to 2 feet 8 inches at the bottom. Very coarse angular tin occurs in the lode along the outcrop. One hundred and twenty feet farther to the south-west is the main shaft. At the date the property was visited, the shaft had been carried down to a vertical depth of 50 feet, at a point about 30 feet south from the outcrop of the lode. At the foot of the shaft, which had been carried down through country rock, a crosscut had been put in to the north for a distance of about 8 feet, at which point the lode was met with (Fig. 57).

The lode, which proved to be very micaceous, had been stripped and showed slickensided faces. Coarse grey angular tin was showing on both walls of the lode, which was about 8 to 9 feet thick. No other work than this appeared to have been done upon the lode. From what was to be seen along the outcrop and in the crosscut at 50 feet below the surface, the impression left upon the

FIG. 57.



SECTION AT THE MAIN SHAFT, CASSITERITE LEASE  
M.L 84 WODGINA, PILBARA GOLDFIELD

mind was that the lode occurred along a line of fault of which several occur in the district.

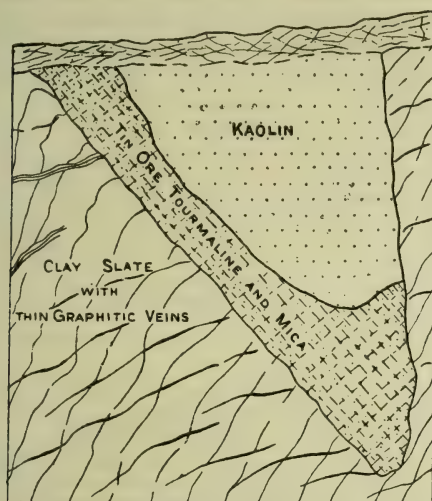
At a point about 500 feet southward from the main shaft is an open cut, 9 feet 6 inches wide, 10 feet deep and about 22 feet in length, put in high up on the face of the range. This excavation shows a wedge-shaped vein, 6 or 7 feet in height, a section of which appears in Fig. 58.

The lode occurs in a somewhat ferruginous clayey slate or quartzite, intersected by numerous graphite veins. The slates contain relatively large quantities of a green mineral [6467]



pinguite, a variety of chloropal. This green clayey-like mineral, when examined in the laboratory, was found, at the hands of Mr.

FIG. 58.



SECTION ON THE CASSITERITE LEASE M.L.84  
WODGINA, PILBARA GOLDFIELD.

Simpson, to consist of  $\text{Fe}_2\text{O}_3$ ,  $\text{SiO}_2$  (32.2 %) and  $\text{H}_2\text{O}$  (20.1 %), together with traces of alumina and magnesia. The lode consists principally of tourmaline and mica, together with tin ore, and is

FIG. 59.



SECTION SHEWING THE POSSIBLE RELATION OF THE VEIN IN FIG  
CASSITERITE LEASE M.L.84. WODGINA, PILBARA GOLDFIELD

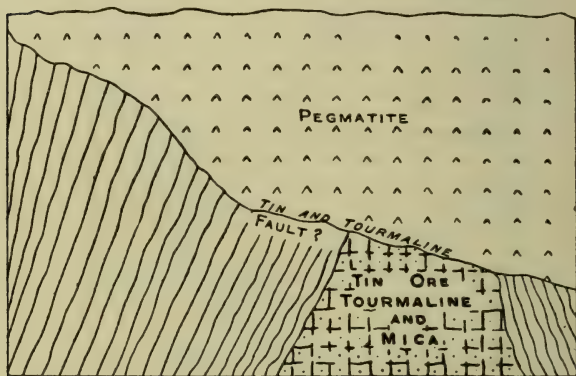
associated with kaolin, which in all probability represents the decomposition product of a pegmatite vein.

What may be called the main pegmatite vein of the Cas-

siterite Lease lies at a point about 40 feet south from this, and it is possible that the vein, exposed in the open cut, probably formed part thereof; the relationship of the two being shown in Fig. 59.

Another open cut, about 13 feet deep, has been put in at a point on the slope of the hill overlooking McCarthy's Creek, distant about 200 feet to the north-west of the main shaft. This open cut shows the following section:—

FIG. 60.



SECTION IN OPEN CUT ON CASSITERITE LEASE M.L. 84  
WODGINA, PILBARA GOLDFIELD

The pegmatite dyke which forms the upper portion of the open cut is about 7 feet thick, where exposed. It rests upon country rock of the usual type, the junction between the two being possibly a line of fault. The footwall of the vein contains a little tin and tourmaline. In the deepest portion of the open cut there is an irregular mass of mica, tourmaline, and tin, about 4 feet thick on its upper surface. It had not, however, been followed to any depth, so its behaviour underground could not be ascertained.

The only other work of any importance done upon the lease is that near the south-west angle, not far from the junction of the greenstones.

At this point, the position of which is indicated upon the geological sketch map, is a vertical shaft, No. 2, which had been carried down to a depth of about 22 feet. A granitic (or pegmatitic) rock was met with at 16 feet from the surface, and at the date of my visit it occupied the whole depth of the shaft. A drive had been put in at 16 feet for a distance of 15 or 16 feet, in a general direction of north 45 degrees east. About 30 feet northward from the mouth of the shaft is the outcrop of one of the large

granitic (or pegmatitic) veins, which traverses a considerable portion of the width of the lease. The relation of this vein to that encountered in the main shaft is not by any means clear (Fig. 61).

An open cut, 25 feet west from the shaft shows, as has been indicated in the figure, several similar thin veins, which in all probability mark the terminal points of offshoots from the main system of dykes. The open cut is 63 feet in length; about 14 feet from the northern end of it is a thin vein, separated by about 16 feet from another, which measures about 12 inches in thickness, but gradually thins out to the surface of the ground. A somewhat thicker vein of about 24 inches makes its appearance at a distance of about 16 feet south from the last mentioned. There seem very good geological reasons for the belief that this vein connects with that met with in No. 2 shaft. Fairly coarse angular tin has been met with at several places in the open cut, and in all probability it owed its origin to one or other of the veins exposed therein.

A fair quantity of stream tin has been obtained by dryblowing that portion of Ogilvie's Gully which traverses the lease. One specimen [6271] from this gully presented by the owners, and now in the Museum of the Geological Survey, weighs 43 lbs.; whilst another fragment (about one-half) of a large crystal [6272] from the same lease, and now on exhibition in the Geological Museum, weighs 28 lbs.

The following table shows the production of tin from this lease so far as can be obtained from official sources:—

*Table of the Tin Yield of the Cassiterite Lease, M.L. 84.*

Year.					Tin Ore Raised.	Value thereof.
					Tons.	£
1904 .	.	.	.	.	6.35	497
1905 .	.	.	.	.	7.50	635
Total . . .					13.85	1,132

M.L. 110, Messrs. GUMMOW, MAY, AND DAWSON.—A lease, which has been applied for, adjoining the north-west corner of M.L. 84, overlooking the West Wodgina townsite, has been the scene of a little prospecting.

A vertical shaft (inaccessible to me) had been put down to a depth of 22 feet through quartzite; the shaft lies some little distance to the west of the small creek flowing northwards, which has been more or less extensively worked for the detrital tin it contains. A few feet west of the shaft a micaceous pegmatite vein has been opened up in one or two places, but no work of any moment has been done upon it. Coarse angular tin was showing in some of the micaceous rock lying near the mouth of the shaft.





be indicated upon the geological sketch map, Plate XIX., of the field. Its position may be approximately located by the shaft upon it, which is situated at a point on the western boundary of the Cassiterite Lease, distant about 500 feet from its north-west angle. An open cut, 45 feet in length, has been put in along the northern edge of the dyke, which is about 40 or 50 feet wide. The dyke, itself, consists of a rock [6467] made up of quartz, a coarsely crystallised, grey, felspar orthoclase, together with about equal proportions of a fine-grained white felspar, which proved, on examination, to be albite. Good, coarse, angular tin occurs along either wall of the dyke, and was showing in the dyke itself. It is stated, upon authority, which may be considered reliable, that about 4 or 5 tons of tin ore had been raised from this spot alone. A shaft was being sunk on the southern wall of the dyke, and at the date of my visit it had been carried down to a depth of about 8 feet, and very good prospects of tin were obtained from the surface, near its mouth. So far as could be judged from what was available for inspection, the northern wall of the dyke appeared to dip to the south at an angle of about 50 degrees, whilst the southern wall seemed to be going down almost vertically. This vein is one of those which passes into the Cassiterite Lease, and adjoins the main shaft on the top of the hill.

GENERAL.—Several other claims have been worked on the field for the residual tin, but they merit no special description.

In addition to the leases, &c., described above, by far the greater portion of the tin so far obtained from Wodgina and Stannum has been derived from the stream and residual deposits. The quantity derived from this source is shown in a tabular form below :—

*Table of the Tin Yield of Sundry Claims of Wodgina.*

Year.	Tin Ore Raised.	Value thereof.
	Tons.	£
1905 . . . . .	12·50	1030
Total . . .	12·50	1030

## THE STANNUM GROUP

*(With a Geological Sketch Map, Plate XX.)*

A group of three tin leases is situated about 8 miles south-west from Wodgina proper, in the heart of the range which extends from the latter locality. Upon these leases are several tin-bearing pegmatitic dykes, which have been more or less exploited, and according to the official figures have produced, up to the end of 1905, 6·20 tons of tin of an estimated value of £365.

A geological survey of the more immediate vicinity of the leases was made, and the results of which are shown on Plate XX. The leases on this map are shown in their relative positions. In its general geological features the country differs in no essential particular from the main mining centre of Wodgina. Granite occupies both sides of the main range, and sends out into the schists, &c., granitic and pegmatitic veins which everywhere form the matrix of the tin ore.

In the vicinity of the Stannum, and occupying a portion of the lease, M.L. 77, is a very large area of intrusive porphyry [6474, 6475, 6476, 6480] which is of later date than the greenstones, &c., which it pierces, and older than the granite and pegmatite veins. The mutual relationship of the two series is shown on the geological map of the group, Plate XX.

From the main mass of the porphyry, which occurs on the Stannum Lease, M.L. 77, and forms the junction of the greenstones and the iron-bearing quartzites, three dykes emanate and are indicated on the map. There are, however, several others which lie outside the area mapped.

This older porphyry varies very much in its general characteristics in different portions of its mass. One variety [6480] is a somewhat fine-grained, flinty-looking rock, which, under the microscope, is seen to consist of plagioclasic felspar, with the characteristic turbid mealy aspect, a little dichroic mica, set in a fine quartzose mosaic.

M.L. 77, STANNUM.—The Stannum Lease, which appears to have been the scene of the first discovery of tin in this portion of the district, is drained by two important creeks, the relative positions of which is shown upon the geological sketch map, Plate XX. The lease is made up of apparently bedded (? cleaved) greenstone, intersected by a mass of porphyry, which seems to have been subjected to the same set of stresses and strains which affected the greenstone which it pierces. These rocks are traversed by a very persistent dyke of pegmatitic granite which traverses the whole length of the lease, after crossing the southern boundary of the property it extends southwards for about 500 feet and far beyond the limits of the area mapped. So far as this dyke, which is but thin, has been traced, it has a length of at least 3500 feet.

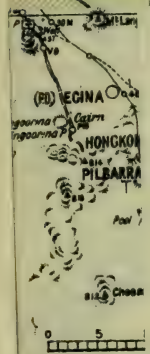
Near the centre of the property two branches of the vein extend for short distances to the east. The northernmost branch has been followed down on the dip for a distance of from 15 to 20 feet, at an angle of 35 degrees; the dyke averages about two feet in thickness. This vein sweeps round the face of the hill to a point about 15 feet from the main shaft, in which it is stated to have been met with at about 18 feet from the surface. The shaft, however, was inaccessible at the date of my visit.

The southernmost branch vein has been opened up to about 5 feet along the dip, which at this point is about 20 degrees to the south; the vein is about 12 inches in thickness and shows tin in



PLATE 10

D



NUM  
PILBARRA

MALTA  
MILITARY

COLOURS





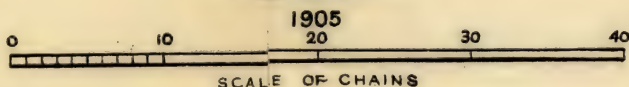
THE HON. H. GREGORY M.L.A.  
Minister for Mines

# GEOLOGICAL SKETCH MAP OF

## THE STANNUM GROUP

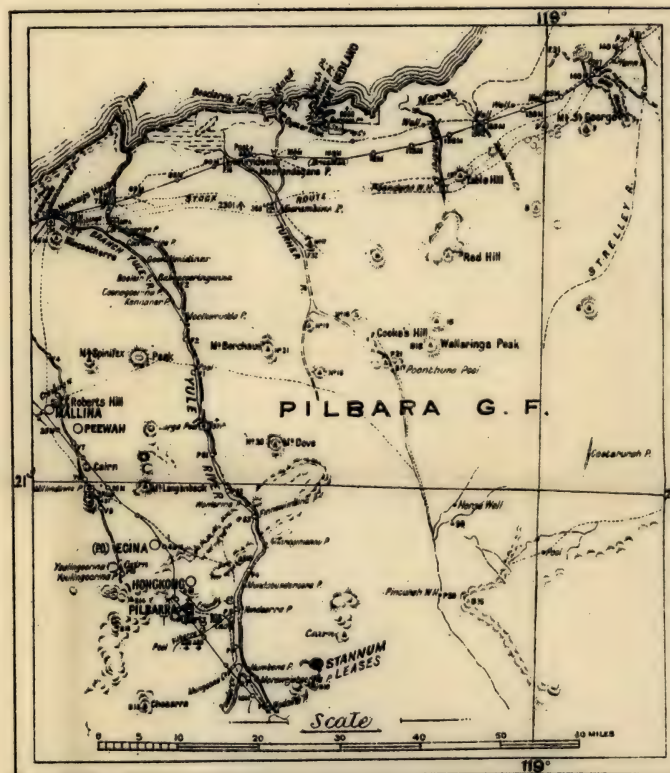
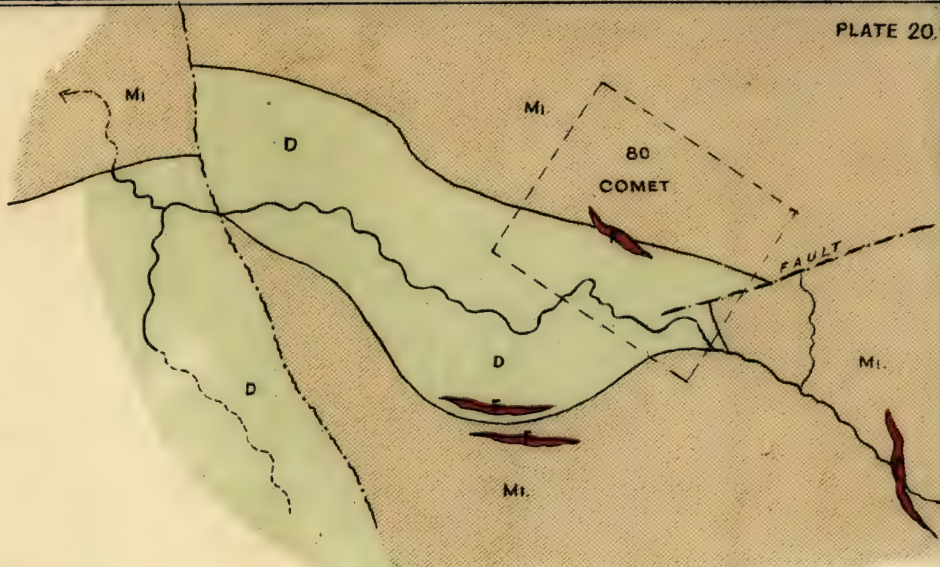
WODGINA. PILBARA G.F.

BY  
A. GIBB MAITLAND,  
GOVERNMENT GEOLOGIST  
AND  
H. W. STALBOT,  
FIELD ASSISTANT.



### EXPLANATION OF COLOURS & SIGNS

ALLUVIAL DEPOSITS.....	
QUARTZITES &c.....	
GREENSTONE.....	
PORPHYRY.....	
PEGMATITIC GRANITE VEINS ( <i>Tin bearing in places.</i> ).....	
FAULTS.....	
GEOLOGICAL BOUNDARIES.....	
MINING LEASES.	<div> <div>Name of.....</div> <div>Number of.....</div> <div>Boundaries of.....</div> </div>
“ EXTINGUISHED.....	<div> <div>STANNUM</div> <div>77</div> <div>COMET 80</div> </div>



Locality Plan.



the faces. At a point on the main vein, distant about 200 feet west of the vertical shaft, it has been opened out for about 10 feet down the dip, which is about 15 degrees in a direction south 15 degrees west. The vein is 12 inches in thickness, and carries very coarse angular tin. Some desultory prospecting has been done at different points along the outcrop of the vein on the property, and judging from what can at present be seen on the surface, a little tin must have been found.

A little distance to the north of the main shaft is an extensive alluvial flat which traverses the northern portion of the lease, and attains a maximum width of about 200 feet.

Upon that portion of the alluvium which lies directly north of the main shaft a fair amount of surfacing has been done and the ground stripped to three or four feet. A fairly large quantity of very clean subangular tin has been obtained therefrom. This tin owes its origin to the disintegration of the granite veins in its proximity. The quantity of tin from this source is probably represented by the yield of this property for 1905, shown in the table below, viz., three-quarters of a ton.

The following figures give, in a tabular form, the total tin yield of the Stannum Lease, so far as can be obtained from the official figures :—

*Table of the Tin Yield of the Stannum Lease, M.L. 77.*

Year.	Tin Ore Raised.	Value thereof.
	Tons.	£
1902 . . . . .	1·00	56
1903 . . . . .	·75	45
1904 . . . . .	2·60	139
1905 . . . . .	·75	60
Total . . . . .	5·00	300

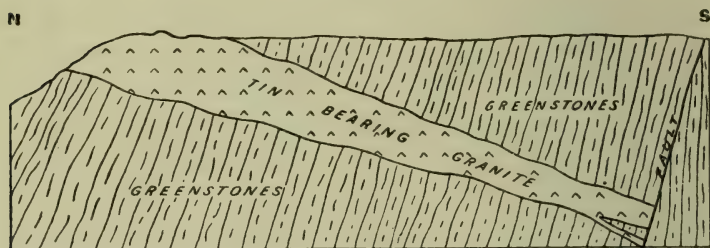
M.L. 79, STANNUM NORTH.—This lease lies on the lower slopes of the main range in the greenstone country, at the foot of the mass of quartzite, which occupies a large area of country in the vicinity. The lease is traversed by two tin-bearing granite veins [6477], which dip to the south at an angle of about 16 degrees. One of these has been opened out in three places. The most extensive of the two veins, "the lode," follows the contour of the hill as indicated on the map, Plate XX., and outcrops in the creek below at a point about 200 feet from the easternmost workings. It has been opened out in three places, the most westerly being a tunnel 32 feet in length driven along the vein, and dipping south at an angle averaging about 16 degrees. The vein is about 4 feet in thickness near the north of the tunnel, but gradually diminishes down the dip. At the face of the tunnel the vein is about 12 inches in thickness.



The section which forms Fig. 62 shows this vein.

M.L. 80, COMET.—The Comet Lease lies on a totally different watershed to that which includes the Stannum group. The ground is situated on the southern slopes of a very high precipitous range, which rises to a considerable altitude above the level of the creek below. The lower portion of the leases is occupied by cleaved greenstone of the type prevailing in the district, which is traversed by several faults, the position of which is indicated on the geological map. The iron-bearing quartzites occupy the higher portions of the country, and make a very prominent feature in the district. As may be seen by an inspection of the geological plan of the lease, Plate XX., the central portion of it near the junction of the two formations is traversed by a small micaceous granitic vein [6471], which carries a little tin. The vein has been opened out by a tunnel driven 50 feet into the face of the hill on a bearing of north 45 degrees east at a considerable elevation above the level of the

FIG. 62.



SECTION OF THE TIN LODGE ON THE STANNUM NORTH M.L.79 WODGINA PILBARA G F

creek. The tunnel has been carried along the vein, which varies from 2 to 3 feet in thickness. At 25 feet, however, from the mouth of the tunnel its place is taken by vertical beds of quartzite identical with those forming the higher ground on the northern portion of the lease. It is possible that the point at which the vein disappears in the tunnel is a fault, of which there are several in the vicinity. Further round the face of the hill to the north-west the same vein has been opened up on the outcrop by a very shallow prospecting shaft, which, however, was inaccessible. A little tin was to be seen in the granite veins forming the dump at the mouth of the shaft.

#### CONCLUSION.

Although the general result of such operations as have been carried out up to the present time indicate clearly that the existence of lode tin in sufficient quantities to be profitably mined has not been demonstrated, owing to the fact that work has hardly yet gone beyond the most rudimentary prospecting stages, there seem

good grounds for the belief that the district bids fair to rise to importance, and that it will continue to be both a tin and a tantalite producer. As the tin in the deposits of the nature of those occurring at Wodgina apparently owes its origin to a separation during the cooling of molten igneous rocks, it is likely to persist to considerable depths provided the continuity of the deposits is not interfered with by faults of later date.

The development of tin lodes, however, is a much more lengthy process than the exploitation of residual and stream tin deposits, and of course cannot be carried out without capital judiciously expended in providing the necessary equipment and in exploration work.

The scarcity of fuel and water, however, is an important factor which, should the deposits on further exploration prove of commercial importance, unless successfully overcome, will act as a deterrent to profitable mining.

*Synoptical Table of the Tin Yield of Wodgina and Stannum.*

Name of District.	Tin Ore Raised.	Value thereof.
	Tons.	£
Wodgina . . . .	12·35	1,007
Stannum . . . .	5·00	300
Sundry Claims . . . .	12·50	1,030
Total . . . .	31·45	2 462

There seem very good reasons for believing that the tin yield disclosed by these figures is considerably under the truth, for the tin buyers apparently only commenced reporting their purchases to the Government towards the close of 1905.

#### THE TANTALITE LODS. (WODGINA. Plate XIX.)

M.L. 86, H.M., and M.L. 87, ANCHORITE.—A very important feature of the Wodgina Field is what is known as the Tantalite lode, the position of which is shown on the geological sketch map of the field. The “lode” traverses the whole length of two of the leases applied for, viz., H.M., M.L. 86, and Anchorite, M.L. 87. Upon the most southerly of the two not very much work has been done, operations having been confined to dryblowing the surface along the outcrop and in the vicinity of the pegmatite vein.

The pegmatite vein (the “lode”) first makes its appearance outside the boundary of the Anchorite ground, to the south of McCarthy’s Creek, and after traversing the whole extent of the two properties, extends northwards far beyond the limits of the geological map. The vein had been opened up in the H.M. ground,





near the southern end of it, and had obtained about one hundred-weight of somewhat fine-grained ore.

What may be called the tantalite group of lodes has been followed with more or less interruption for about a mile to the north of M.L. 86, and eventually merges into the granite mass of the plains. A fair quantity of detrital tantalite has been obtained from this locality, and there is every reason to believe that the area over which the mineral occurs will be extended.

According to the returns taken from the *Government Gazette*, the yield of tantalite has been, up to the close of 1905, as shown in the table below :—

*Table of the Tantalite Yield of Wodgina.*

Name of Lease, &c.	Ore Raised.	Estimated Value.
	Tons.	£
H. M. and Anchorite, M.Ls. 86, 87	26·00	3,425
Naismith's Unreg. Claim . . .	45·60	5,500
Total . . .	71 60	8 925

**EADIE'S CLAIM.**—On a bearing of 358 degrees, and distant about 78 chains from M.L. 86, is what is known as Eadie's Claim, upon which is a pegmatite dyke of the prevailing type and containing a little tantalite. The dyke measures about 20 feet in width on the surface, and occurs in greenstone country identical with, and the continuation of, that occurring in McCarthy's Creek.

The only work done, however, consisted in opening up the dyke to a depth of about 3 feet. This deposit is virtually the continuation of the main tantalite lode previously described, which can be followed more or less continuously to this point, near which it disappears into the low country of the plains.

Nine hundred feet distant, on a bearing of 305 degrees, is a dryblown patch occurring on a pegmatite dyke of the ordinary type. A fair quantity of detrital tantalite had been obtained from this locality at the date of my visit.

**MOUNT YORK.**—A recent report from the Acting Inspector of Mines (submitted to the Minister for Mines in January last) on the occurrence of tantalite at Mount York<sup>1</sup> (Chingamong), about 20 miles east of Wodgina, in a mineral belt which trends generally north and south, and parallel to that at Wodgina, describes the only workings in the district :—

“On M.L. 100 (O. T. Bell and party) a rubbly felspar formation has been exposed for a few feet. This carries tantalite, but sufficient work has not been done to allow of an opinion as to the

<sup>1</sup> The position of Mount York is not shown on any of the official maps, and has probably not been fixed.

richness of the lode. On McBeth's alluvial reward claim (applied for) tantalite can be easily seen in the gully that traverses the claim. . . . Several tin lodes have been pegged out in this locality, but little if any work has been done on them."

The "felspar formation" which the Inspector describes is without doubt one of the pegmatitic dykes which occur in such great force at Wodgina.

No opportunity presented itself of visiting this find, but on my way to Perth I was shown at Lalla Rookh, by Mr. Wm. Walsh, one of the owners of the find, a large quantity of dressed tantalite, a sample of which was assayed in the Survey Laboratory and yielded:—

Metallic tin . . . . .	15·62 per cent.
Tantalum pentoxide, $Ta_2O_5$ . . . . .	42·39 „
Niobium pentoxide, $Nb_2O_5$ . . . . .	21·09 „

In this sample much of the tantalite occurred in the form of well-defined crystals.

The occurrence of tantalum ores has been known in the State for a number of years, full particulars of which have been available in several of the Bulletins of the Survey.

Tantalum was recorded as occurring in this State at Greenbushes, viz., Stibiotantalite (tantalate of antimony) in 1894.<sup>1</sup> In 1900, Tantalite (tantalate of iron) was detected in the Survey Laboratory, in some of the alluvial wash from the Greenbushes Tinfield; Manganotantalite (tantalate of manganese) in 1904, in material sent in from Wodgina; and in 1905, Manganocolumbite (niobiate and tantalate of manganese) and Calciotantalite (tantalate of iron and lime) from Wodgina and Mount York (Chingamong).

An analysis of a sample of manganotantalite [6459] from lease M.L. 86 has been made in the Survey Laboratory by Mr. E. S. Simpson:—

$Ta_2O_5$ . . . . .	68·65
$Nb_2O_5$ . . . . .	15·11
$TiO_2$ . . . . .	·40
$SnO_2$ . . . . .	·48
$WO_3$ . . . . .	Trace
$H_2O$ (combined) . . . . .	·07
$FeO$ . . . . .	1·63
$MnO$ . . . . .	14·15
$NiO$ . . . . .	Trace
$CaO$ . . . . .	Trace
$MgO$ . . . . .	·15
$(Ce, Y)_2O_3$ . . . . .	Nil
	<hr/> 100·64 <hr/>

Specific Gravity . . . 7·03

<sup>1</sup> J. J. East. On Stibiotantalite, a new mineral from the Stanniferous Gravel at Greenbushes, Bunbury, Western Australia. Trans. Aust. Inst. Mining Engineers, 1904, Vol. i., pp. 139-142.

The tantalite of Wodgina, as may be seen by a reference to the various analyses, contains a fairly large percentage of the comparatively useless niobium oxide. The recently announced discovery<sup>1</sup> of the perfection of a method for the separation of the tantalum oxide and niobium oxide is of importance, as it may eventually give a commercial value to those tantalite deposits which, owing to the high percentage of niobium, are at present practically useless.

Having due regard to the uses to which recent scientific research has proved the metal can be put, provided the tantalum-bearing minerals can be obtained in sufficient quantities, the find at Wodgina is of considerable importance, and should be the means of encouraging prospecting in other districts in which identical geological conditions prevail.

The following account of tantalum, its detection and uses, has been drawn up by the Mineralogist and Assayer, Mr. Simpson:—

## TANTALUM

### ITS DETECTION AND USES.

Tantalum, and its so far valueless twin brother Niobium, which always accompanies it in nature, were discovered as long ago as 1801. It was not, however, till the year 1904 that tantalum was prepared in a state of great purity and its intrinsic qualities determined. Tantalum is prepared by passing a strong current of electricity through a rod of the pure oxide in a continually maintained vacuum, and also in an equally pure state by fusing potassium tantalum fluoride with metallic potassium in an evacuated electric furnace.

Thus prepared, tantalum is a hard grey metal, considerably heavier than silver but lighter than gold. It is very ductile, and can be drawn out into the thinnest wire. At the same time, when hammered it becomes harder than the hardest steel, and has therefore been suggested as a substitute for the diamond in drilling. In a vacuum its melting point is found to be higher than that of platinum, but when heated in air it becomes oxidised—superficially only at a red heat, completely at a white heat. It is unaffected by all mineral acids except hydrofluoric.

Its present use is confined to providing filaments for incandescent electric lamps. For this purpose it is found to be extremely well suited, having a long life and using only about half the usual amount of current for the same candle power. The demand for these lamps is already so large that the patentees, Messrs. Siemens & Halske, are unable, with an output of 5000 per day, to satisfy the demand. One kilogramme (a little over two pounds avoirdupois) of tantalum is sufficient for the production of 45,000 lamps. Its alloys with iron are found to combine great hardness and durability with ease of working, and it is probable that they will be put to some use in the near future.

Passing now to the question of the natural supplies of the metal, it may be stated at the outset that tantalum does not occur in the metallic state in nature, but only in a few rare and complex compounds of the oxides of tantalum and niobium with the oxides of other metals. The most important of these are:—

*Tantalite* (tantalite and niobate of iron and manganese).—This is the commonest and most important ore and comprises several varieties, dis-

<sup>1</sup> The Mining Journal, London, 28th October 1905.



tinguished by differences in crystalline form, and in the relative amounts of tantalum, niobium, iron, and manganese present. They are as follows :—

Tantalite, tantalum pentoxide . . . . .	43 to 85 per cent.
Manganotantalite, tantalum pentoxide . . . . .	43 to 85 „
Columbite, tantalum pentoxide . . . . .	1 to 42 „
Manganocolumbite, tantalum pentoxide . . . . .	1 to 42 „
Skogbolite, tantalum pentoxide . . . . .	43 to 85 „

Typical tantalite occurs at Greenbushes, manganotantalite at Wodgina (Pilbara G.F.). At this latter locality there also occurs a new variety, characterised by the presence of a high proportion of lime (7·8 per cent.).<sup>1</sup> Specific gravity, 5·3 to 7·9. Colour, black; opaque.

*Microlite* (tantalate and niobate of calcium).—Tantalum pentoxide, 68 per cent. Specific gravity, 5·3 to 6·1. Colour, yellow to brown; transparent to translucent.

*Stibiotantalite* (tantalate and niobate of antimony).—Tantalum pentoxide, 51 per cent. Occurs at Greenbushes. Specific gravity, 6·4 to 7·4. Colour, grey, yellow, or brown; translucent or opaque.

*Ytrotantalite* (tantalate and niobate of yttrium, iron, &c.).—Tantalum pentoxide, 46 per cent. Specific gravity, 5·4 to 5·9. Colour, yellow, brown, black; opaque.

*Fergusonite* (tantalate and niobate of yttrium, erbium, &c.).—Tantalum pentoxide, 2 to 43 per cent. Specific gravity, 4·7 to 5·8. Colour, brownish black; opaque.

*Samaraskite* (tantalate and niobate of iron, uranium, &c.).—Tantalum pentoxide, 2 to 18 per cent. Specific gravity, 5·0 to 6·0. Colour, black; opaque.

Tantalum-bearing minerals are usually found in granitic country, either in pegmatite veins or bands in the rock mass, or in surface and stream boulders and pebbles derived from them. Tin ore is sometimes associated with them, so that tin concentrates should be examined for their presence. It was in this way that they were first detected at Greenbushes.

There is no simple blowpipe or other test for the presence of tantalum. It is useful, however, to remember that minerals containing notable amounts of this metal are all extremely heavy. A considerable amount of time has been devoted by the author to the question of the detection and assay of tantalum ores, and the following methods have been evolved :—

*Detection.*—The suspected mineral or black sand or tin concentrate is ground to an impalpable powder in an agate mortar, and half as much as will go on a threepenny piece (say  $\frac{1}{2}$  gramme) is fused in a nickel crucible at a red heat with six times its weight of caustic potash. The crucible is cooled and the melt dissolved out with hot water and put in a beaker with a moderate excess of dilute hydrochloric acid, and boiled. If a creamy white opaque flocculent precipitate forms immediately, tantalum or niobium or both are present, and the material should be subjected to a complete assay as described below. Care must be taken not to confuse with this the precipitate of titanium hydrate formed under somewhat similar circumstances. If sufficient acid is present the latter will not form at all, but if only slight excess of acid is present it will form *slowly* on warming, gradually becoming heavier. It is finely granular as compared with the tantalum precipitate.

The value of tantalum ores depends principally upon the percentage of tantalum pentoxide ( $\text{Ta}_2\text{O}_5$ ) in them, but is lessened in proportion to the percentage of niobium pentoxide ( $\text{Nb}_2\text{O}_5$ ) associated with it. Roughly, ore is worth in London £1 per unit, the market being very unsettled owing to the demand at present being very restricted. Quotations twelve months ago

<sup>1</sup> A rounded pebble [6286] weighing 18 grammes, and grey-black in colour, had a sp. gr. of 6·04 and the following composition :— $\text{Ta}_2\text{O}_5$  73·82,  $\text{Nb}_2\text{O}_5$  6·44,  $\text{SnO}_2$  72,  $\text{TiO}_2$  54,  $\text{FeO}$  8·42,  $\text{MnO}$  1·39,  $\text{CaO}$  7·78,  $\text{MgO}$  62,  $\text{Ce}_2\text{O}_3$  nil—total, 99·73.

(June 1905) ranged from 3½d. per lb. for 5 per cent. ore up to 18s. per lb. for 80 per cent. ore.

The following determinations have been made on ores from this State:—

Tantalite, Greenbushes . . .	Ta <sub>2</sub> O <sub>5</sub> 80·61 % .	Nb <sub>2</sub> O <sub>5</sub> 2·50 %
Stibiotantalite, Greenbushes . . .	68·50 „ .	5·46 „
„ „ . . .	51·13 „ .	7·56 „
„ „ . . .	50·57 „ .	12·58 „
„ „ . . .	51·95 „ .	4·49 „
Manganotantalite, Wodgina . . .	69·95 „ .	14·47 „
„ „ . . .	72·46 „ .	6·80 „
Calciotantalite, Wodgina . . .	73·82 „ .	6·44 „
Manganotantalite, Green's Well . . .	54·76 „ .	27·24 „
Tantalite, near Lalla Rookh . . .	70·34 „ .	4·92 „

The above assays are mainly those of bulk samples. Individual fragments from the Wodgina Field are very variable in specific gravity, and therefore also in assay value. The observed range is from 5·50 (=10 per cent. Ta<sub>2</sub>O<sub>5</sub>) to 8·03 (=84 per cent. Ta<sub>2</sub>O<sub>5</sub>).

Samples of these ores are to be seen in the Geological Survey Office, Beaufort Street.

*Assay.* 1. Simple rough Method for Buyers.—A close relationship exists between the specific gravity of tantalite and its varieties and the very variable percentage of tantalum pentoxide contained in them. In buying, therefore, clean tantalite free from tin ore, &c., a rough assay (to be subsequently checked by a chemical method) may be made as follows:—The specific gravity of several of the fragments of mineral is taken carefully, and their mean calculated, or the specific gravity of a representative portion of the coarsely crushed sample is taken, and the percentage of Ta<sub>2</sub>O<sub>5</sub> taken from the following table:—

Specific gravity		Iron-tantalite.		Mangano-tantalite.	
		Ta <sub>2</sub> O <sub>5</sub> %	Trace		
5·3	„	„	6	„	2
5·5	„	„	14	„	10
5·7	„	„	22	„	19
5·9	„	„	30	„	27
6·1	„	„	38	„	36
6·3	„	„	45	„	44
6·5	„	„	52	„	51
6·7	„	„	59	„	59
6·9	„	„	65	„	66
7·1	„	„	70	„	72
7·3	„	„	75	„	78
7·5	„	„	79	„	83
7·7	„	„	84	„	...
7·9	„	„		„	...

This is usually correct to within less than 5 per cent.

2. Chemical Method.—The method here described is not applicable to stibiotantalite, as it does not effect a separation of Sb from Ta and Nb. It must be modified somewhat when the Ta<sub>2</sub>O<sub>5</sub> present is not greater than one-tenth of the Nb<sub>2</sub>O<sub>5</sub>.

*Decomposition.*—Crush ore through a 90 sieve and mix well. Put between three and four grammes of pure KHO in a 1½-inch nickel (or silver) crucible, cover and set over gauze to melt whilst ore is weighed out. Weigh out 0·5 gramme of ore, grinding it all very carefully in an agate mortar in lots of not more than 2 gramme before putting it on the weighed watch-glass. By the time weighing is completed the KHO will be in a state of tranquil fusion. Remove burner and drop in the ore, mix well by quickly rotating, replace on gauze, cover and heat for 10 minutes. Remove lid and repeat rotation, then set crucible in a 1⅜-inch hole in a sheet of one-eighth inch asbestos so that not more than one-third of the crucible projects below. Cover and heat

over naked bunsen for half-hour so that bottom of crucible is bright red. The melt is very liable to creep, but this is avoided by heating over asbestos support as here described. At the end of half-hour fusion is complete, and bunsen is removed. Remove cover carefully so as to avoid losing any of the liquid melt from its under surface. Set lid aside upside down to cool, and cant the crucible well to one side when cooling so that the greater part of the melt solidifies on the side, which makes subsequent solution rapid. While cooling, measure out 30 cc. 5E.HCl, and pour about 10 cc. into the bottom of a beaker of not less than 400 cc. capacity. Wash the lid off into this first with warm water, then with a little of the measured acid, rub well with a "policeman,"<sup>1</sup> and finally wash again with water. Cover crucible with a watch glass, and through a small gap on the side away from the melt fill the crucible two-thirds full with slightly warm water from a wash bottle. Action is somewhat violent for a few seconds. When it is tranquil, decant into the beaker, wash well with warm water, then with the remainder of the measured acid, rub well with policeman, and finally wash well with water.

*Determination of  $Ta_2O_5$  and  $Nb_2O_5$ .*—Add to the solution, which should not now measure more than 80 or 90 c.c., 5 to 10<sup>2</sup> c.c. of 10E HCl and set on sand bath to boil. (The original solution of the melt is usually green from presence of  $K_2MnO_4$ , on acidifying with acid the colour changes to red from the formation of  $KMnO_4$ ,  $MnO_2$ , and hydrates of Ta and Nb being precipitated at the same time. On boiling both  $KMnO_4$  and  $MnO_2$  are attacked, giving  $MnCl_2$ , and liberating  $Cl_2$ , whilst Ta and Nb hydrates remain insoluble except in traces. Boil the solution till all  $Cl_2$  is driven off and the precipitate is no longer brown, but creamy white. Dilute to 200 c.c. and boil for a further 15 minutes to ensure complete precipitation of the Nb. Filter through a 12 c.m. paper, pouring supernatant liquor through first without disturbing precipitate, the filtration being thus hastened. The filtrate should be quite clear; if milky it probably contains Nb, which must be precipitated by further diluting and boiling. Wash precipitate on filter with boiling water until washings give no reaction with  $AgNO_3$ . Residue consists of hydrates of Ta, Nb (and W?), with all Sb, and at times traces of  $Mn_3O_4$  and  $SnO_2$ . Filtrate contains all Sn, Fe, Mn, Ca, Mg, Cu, Ni, and Ti as chlorides. The filter and residue are almost completely dried in a water oven, folded up and put in a covered and weighed porcelain crucible, and heated up gradually in a gas muffle or otherwise. When nearly red remove lid and heat to bright redness, till all carbon is burnt off, then ignite a further 15 minutes. Cool in desiccator, and weigh as  $Ta_2O_5 + Nb_2O_5$ .

*Separation of  $Ta_2O_5$  and  $Nb_2O_5$ .*—All Ta and Nb must first be obtained in the form of hydrates, either by fusing a fresh portion of ore as before, or by treating the weighed oxides in the same way as an ore. In the latter case the fused KHO must be cooled until solid before addition of the oxides, otherwise loss may occur.

It is convenient to use for the separation four platinum dishes, one each 2", 2½", 3", 3½".

The well-washed hydrates are washed almost completely off the filter into a 3" platinum dish. The filter is then folded into four inside out, and put in a second (3½") platinum dish, covered with hot water and a few drops of HF added, and the solution warmed on a sand bath for a few minutes. Pour off the solution into the dish containing the Ta and Nb, repeat the operation, and finally wash the filter at least four times by decantation with hot water. Set solution of Ta and Nb on sand bath to heat, and if solution of hydrates is not complete in a few minutes add one or two drops more HF, avoiding carefully any great excess. Weigh, roughly, 0.7 gram of dry KF (or more if moist), dissolve in hot water, and after heating both solutions nearly to boiling, add the KF slowly, with stirring, to the solution of Ta and Nb. Evaporate to 10 c.c. Wash down sides of basin with a few drops of hot water and set on one side to cool slowly down to 15° C. When

<sup>1</sup> "Policeman"—a glass rod with a small cap of rubber tubing.

<sup>2</sup> The larger quantity is used when much Ti is present. 5 cc. is sufficient when only a little Ti or Mn are present.



thoroughly cool, decant clear solution containing all Nb and part of Ta through a 7 cm. filter into a small ( $2\frac{1}{2}$ " ) platinum dish. Wash residual felted mass of spicular crystals of  $K_2TaF_7$  with four small lots of cold ( $15^\circ$ ) water, adding washings to main solution. Evaporate over water bath to about 5 c.c., cool slowly as before. Decant or filter off solution through a small (7 cm.) filter, supported on a well-waxed glass funnel, into a 2" dish. Wash with four small lots of cold ( $15^\circ$ ) water and examine residue for flat plates of  $K_2NbOF_5$ . If present, they must be removed by further washing. Evaporate solution to dryness at  $100^\circ$ , cool, add one drop HF and dissolve 0.1 gram of KF in 1 c.c. of water. Then run into dish from a burette from 1 to 5 c.c. or more (usually 3 c.c.) water according to proportion of Nb expected to be present, viz., about 1 c.c. for every 7 per cent.  $Nb_2O_5$ . Heat rapidly for a few seconds to dissolve all residue, add the solution of KF, and make note of bulk of total solution, and set on one side to cool for one hour at  $15^\circ$  C. or thereabouts.<sup>1</sup> Filter solution into a small platinum dish and wash residue three or four times with a few drops of water at  $15^\circ$  or less, making a note of the approximate bulk of the washings. Add to solution 8 c.c. 10E  $H_2SO_4$  and evaporate to fuming on a sand bath. Keep strongly fuming for at least 20 minutes in order to remove last traces of fluorine. See that no unattacked fluorides remain on the side of dish out of reach of the sulphuric acid. Cool and pour into 150 c.c. water contained in a 300 or 400 c.c. beaker. Wash out dish well with chilled water and a policeman. Boil solution for 20 minutes to precipitate all Nb and Ta associated with it, filter, wash well with boiling water and dry. Ignite until all filter is burnt, cover, add 1.0 gm. solid ammonium carbonate, cover and reignite till constant in weight. Weigh the residue which contains all the  $Nb_2O_5$  and part of the  $Ta_2O_5$ . The latter is allowed for on the following basis, viz., .00365 gm.  $Ta_2O_5$  for every 1 c.c. of the solution in which the final crystallisation took place, and .00091  $Ta_2O_5$  for every 1 c.c. of wash water used in the final filtration.

*Determination of Tin.*—Warm the main solution containing the chlorides of Sn, Fe, &c., and pass  $H_2S$  to saturation. Filter off the  $SnS$  and wash well with  $H_2S$  water. Convert into  $SnO_2$  as usual, and weigh after ignition.

### R.—Cooglegong Tinfield

The Cooglegong Tinfield is situated on one of the tributaries of the Shaw River, a little to the west of the White Quartz Hill shown upon the geological sketch map of the Pilbara Goldfield, which forms the frontispiece of this report. The field is claimed to have been discovered in August 1900, and since that date it has (*i.e.* up to 1906) returned 760.35 tons of tin ore, valued at £52,179.

### GENERAL GEOLOGICAL FEATURES.

As is the case at Moolyella,<sup>2</sup> the Cooglegong Tinfield presents a marked uniformity in its geology, the whole area consisting of granite, which in some places is gneissose in structure. The granite covers a wide expanse of country; it extends over an area of some hundreds of square miles, and, as may be seen by an inspection of the geological sketch map of the Pilbara Goldfield (Frontispiece), it appears to form part of the large mass which extends, with more or less interruption, from Corunna Downs to the Yule River. This area embraces the country which took in the old Shaw River Tin-

<sup>1</sup> N.B.—Note more than  $2^\circ$  above or below  $15^\circ$  C. 1 c.c. solution acidified with H F holds in solution at  $15^\circ$  .00365 gms.  $Ta_2O_5$  as  $K_2TaF_7$  or .03650 gms.  $Nb_2O_5$  as  $K_2NbOF_5$  (on .5 gm. charge 0.73%  $Ta_2O_5$  and 7.3%  $Nb_2O_5$ ).

<sup>2</sup> Geol. Surv. Bulletin 15. Perth: By Authority, 1904, pp. 102 *et seq.*

field, which, so far as may be gathered from the official figures, has been responsible for 145·34 tons of tin, valued at £151,219.

As only four days were spent in the locality, there was very little opportunity of doing more than making a very cursory inspection of the more salient features of the district as a whole. The western margin of the granite is in close proximity to the White Quartz Hill, which forms the culminating point of a long and wide quartz reef, which has an average strike of 173 degrees and forms one of the most conspicuous features in the landscape, visible for many miles in nearly every direction.

The granite is principally composed of quartz, felspar, and mica, and presents a great uniformity in its composition over wide areas. As is the case elsewhere in the district, the granite is intersected in certain localities by veins of pegmatite, which have doubtless been the original source from which the stream and residual tin has been derived. All the tin hitherto obtained from the district has been derived from the alluvial deposits which have been formed in the existing valleys. So far as has at present been observed, these alluvial deposits do not attain any very great thickness, although their width must in many cases be very great.

As none of these alluvial deposits have as yet been geologically mapped, not very much can be said as to their extent, though there seem very good scientific grounds for the belief that systematic and judicious prospecting will result in the discovery of other deposits quite as rich as any of those yet opened up.

There is, in addition to the alluvial deposits, a fairly large quantity of residual tin, *i.e.* ore derived from the wear and tear *in situ* of the tin-bearing pegmatite granites which traverse certain portions of the granite massif.

Considerable interest attaches to the district on account of the occurrence of the mineral gadolinite, a silicate of yttrium, lanthanum, beryllium and iron, associated with the stream tin. The occurrence of gadolinite in granite from Cooglegong Creek was noticed in the Annual Report of the Geological Survey for the year 1900,<sup>1</sup> and specimens [2027, 6495] of it are now in the collection of the department. The presence of numerous pegmatitic granite dykes throughout the district, and the known occurrence of tantalum-bearing minerals in one at Wodgina (p. 273 *et seq.*) suggests the possibility of these being the matrix of the gadolinite. In other parts of the globe the rarer minerals, Thorianite, Yttrialite, Fergusonite, Allanite, &c., have been found occurring in similar pegmatite dykes, and there is but little doubt that careful search throughout the North-West district would result in the discovery of some of the rarer earths of which at the present there appears to be a considerable demand.

During the course of the field work search was made for the vein in which gadolinite is stated to have occurred, but without success. One very pronounced vein, 3 or 4 feet in thickness, and upon which a little prospecting work had been done, was found to

<sup>1</sup> Ann. Prog. Rep. Geol. Surv., 1900. Perth: By Authority, 1901, p. 32.

contain [6494] large quantities of garnets, both in the massive form and as crystals.

The only analysis yet made of this gadolinite was made by Mr. B. F. Davis, of Sydney, and is as follows:—

Silica, $\text{SiO}_2$	23.33
Iron Protoxide, $\text{FeO}$	10.38
Beryllium Oxide, $\text{BeO}$	12.28
Cerium Sesquioxide, $\text{Ce}_2\text{O}_3$	2.50
Lanthanum Sesquioxide, $\text{La}_2\text{O}_3$	18.30
Didymium Sesquioxide, $\text{Di}_2\text{O}_3$	
Yttrium Sesquioxide, $\text{Y}_2\text{O}_3$	33.40
Magnesia, $\text{MgO}$	.69
Ignition Loss, $\text{H}_2\text{O}, \text{N}_2, \text{CO}_2$	.32
	<u>101.20</u>

Specific Gravity . . . 4.14

*Table showing the Tin Yield of Cooglegong.*

Year.	Tin Ore Raised.	Value thereof
	Tons.	£
1900 . . . . .	65.06	3,687
1901 . . . . .	174.43	8,880
1902 . . . . .	91.80	6,373
1903 . . . . .	173.59	12,541
1904 . . . . .	114.34	8,664
1905 . . . . .	141.13	12,034
Total . . . . .	760.35	52,179

The following table shows the yield of the Old Shaw Tinfield, so far as can be gathered from official figures:—

*Table showing the Tin Yield of Old Shaw.*

Year.	Tin Ore Raised.	Value thereof.
	Tons.	£
1893 . . . . .	<sup>1</sup> 56.45	3,470
1894 . . . . .	<sup>1</sup> 19.00	949
1895 . . . . .	<i>Nil</i>	...
1896 . . . . .	<i>Nil</i>	...
1897 . . . . .	<i>Nil</i>	...
1898 . . . . .	<i>Nil</i>	...
<sup>2</sup> 1899 . . . . .	<i>Nil</i>	...
1900 . . . . .	4.00	300
1901 . . . . .	7.35	357
1902 . . . . .	19.00	1,267
1903 . . . . .	14.02	981
1904 . . . . .	80.57	6,107
1905 . . . . .	17.65	1,394
Total . . . . .	218.04	14,825

<sup>1</sup> Customs records.

<sup>2</sup> Prior to 1900 the Mines Department records show only 2.75 tons, valued at £124.



## PART III.—GENERAL SUMMARY

The efforts which had been made by private enterprise towards the development of mining in the Pilbara Goldfield seemed to warrant such assistance and guidance as might be afforded by a reasonably accurate delineation of those salient geological features which had any bearing upon economic questions.

During the three field seasons spent in the district, visits were paid to, and such a detailed examination as the circumstances seemed to warrant made of, all the centres where mining was being, or had been, carried out. The three reports<sup>1</sup> may, therefore, be regarded as the results of an attempt at a systematic and reasonably detailed examination of the broader geological features of the Pilbara Goldfield, in so far as they have any bearing upon economic questions.

Whilst by far the larger portion of the reports is the direct result of my own personal observations, the manuscript reports of the Inspectors of Mines have been laid under contribution when considered necessary. The knowledge thus gained is graphically summed up on the general geological sketch map, which forms the frontispiece to this report.

The district affords better and more continuous sections than are generally to be met with on any of the goldfields of the State which have yet been examined; they thus reveal geological structures which are not to be found in the more southerly districts, and, on this account, serve to throw light on many obscure points in connection with the geology of other fields.

### GENERAL GEOLOGY

The following is the geological record arranged in the form of a table, as furnished by the Pilbara Goldfield :—

Recent. . . . .	Blown Sand. Alluvium of the River Beds. Residual Deposits.
Oakover Beds . . . .	Sandstones, Limestones, &c.
(Age ?)	
Nullagine Beds. . .	Sandstones, grits, conglomerates and volcanic rocks. ( <i>Gold bearing in places.</i> )
(Age ?)	
Mosquito Creek Beds	Grits, shales, and fine conglomerates. ( <i>Gold bearing in places.</i> )
(Age ?)	
Warrawoona Beds .	Metamorphic sedimentary rocks, quartzites, conglomerates, greenstone schists, and allied rocks. ( <i>Gold bearing.</i> )
(Archæan ?)	
Granite and Gneiss .	( <i>Tin and Tantalite bearing and auriferous in places.</i> )
Dolerite, Diabase, and Gabbro Dykes.	

The OAKOVER BEDS have only been noticed, up to the present, in

<sup>1</sup> Geol. Surv. Bulletins, Nos. 15, 20, and 23.

the country in the vicinity of the Oakover River, below Carawine Pool. The beds consist of a series of sandstones, limestones, and cherts, which have yielded no fossils, and which are not very thick. These beds rest with a violent unconformability upon an older series of limestones and volcanic rocks. There is no evidence as to their geological age.

The NULLAGINE BEDS are largely developed in the Pilbara Goldfield, and consist of a great thickness of sandstones, grits, conglomerates, and limestones, some of which are magnesian, together with a series of lavas, ashes, and agglomerates of, as yet, unascertained thickness. The formation makes a prominent feature in the landscape of the district, and plays a very important part in the geology of the North-West. It may be followed from the Oakover River, across the upper reaches of the Nullagine, the Coongan, and the Shaw Rivers, as far as the western boundary of the goldfield, on the Yule River, near Cangan Pool. Areas of more or less extent make their appearance at Just-in-Time, Talga Talga, and North Pole, on the Shaw. The formation is of some economic value by reason of the fact that the basal members of the series have proved to be auriferous in two localities, several miles apart, viz., Nullagine and Just-in-Time.

The Nullagine Beds cannot be exactly correlated with any of those yet described in any of the previous official reports on the geology of Western Australia, owing to the absence of fossils throughout the series, wherever it has yet been studied. Under these circumstances, petrographical resemblance seems to be the only method by which any clue can, in the present condition of our knowledge, be arrived at with respect to its age. In its lithological characters and general behaviour it bears a very strong resemblance to the quartzites, &c., which constitute that continuous formation extending from Wyndham to Mount Hart, a prominent summit on the King Leopold Range in Kimberley, which have been claimed as Cambrian. If further research should indicate this resemblance to possess greater significance than at present appears, the Cambrian Age of the Nullagine Series would have strong claims for consideration.

The MOSQUITO CREEK BEDS, which underlie the strata of the Nullagine Series, comprise one of the oldest of the sedimentary formations as developed in Pilbara. The series consists of grits, shales, and fine conglomerates, an approximate estimate of the thickness of which cannot be determined, though it is possible that the great thickness may be due to the repetition of the beds by folding.

What seems to be the base of the Mosquito Creek Series is exposed a little to the east of Nullagine in what are known as the North and South Dromedaries. The range in which the beds are exposed consists of vertical beds of conglomerate of considerable thickness. The conglomerate is very much cleaved, and the cleavage planes are seen to cut through the centre of many of the

quartz and other pebbles contained in it. The conglomerate contains numerous pebbles and boulders of laminated quartz (chert?), belts of which form such conspicuous features in the Pilbara Goldfield,

No trace of fossils has been met with anywhere in the series, so no definite data as to the age of the Mosquito Creek beds is available. Observations in the field have shown that these strata lie with a violent unconformity beneath the Nullagine beds, and as in certain portions of the district the Mosquito Creek Series have been subjected to more or less dynamical alteration, a considerable period must have elapsed between the deposition of the two series. The Mosquito Creek beds are of economic importance by reason of the fact that they form the matrices of the numerous auriferous quartz reefs which outcrop over a portion of the district, and have been more or less perfunctorily worked.

**WARRAWOONA BEDS.**—In the neighbourhood of Warrawoona are a series of metamorphic rocks, which occupy a large area of country which forms a continuous belt from Marble Bar to Yandicoogina. These metamorphic rocks can be separated into two distinct sets, which are sharply differentiated from each other, viz., an acidic and a basic series.

The acid series is made up of highly siliceous beds dipping at varying angles to the north-east and trending generally north-west and south-east. These beds, which there are very good reasons for believing to be of sedimentary origin, consist of fine-grained flaggy quartzites, sheared conglomerates, which still retain traces of their original character, mica and quartz schists, together with certain fine-grained siliceous rocks, which seem to have lost all trace of their original character. There are in intimate association with these certain other acidic rocks, which may eventually prove on closer examination to be highly-sheared felsites. The basic series occupy a large area of country and vary very much in the width of their outcrop. A very important feature in this series is the presence amongst the beds of a series of unfoliated rocks, which sometimes occur in the form of lenticular belts of, in certain cases, considerable horizontal extent. In one or two localities are belts of magnetite schist, in the centre of some of which are uncrushed "eyes" of greenstone (of large dimensions), occurring in such a way as to indicate that the margins only have been crushed down into schist. The massive greenstones vary very much in grain; they all contain more or less hornblende and its numerous alteration products; some of its constituent minerals being largely replaced by carbonates.

These Warrawoona Beds are traversed by bands of laminated chert (?) which invariably occur in close proximity to, and in intimate association with, the auriferous quartz reefs.

The Warrawoona Beds are of considerable economic importance by reason of the fact that they carry all the auriferous reefs of Marble Bar, Salgash, Warrawoona, and Yandicoogina.



**GRANITE AND GNEISS.**—The Granite and gneiss, which occupies such an extensive area of country throughout the field, is almost everywhere seen to be intrusive into the oldest rocks of the district, indicated as the Warrawoona Beds. In no case has the granite been noticed rising to the level of, and piercing the newer rocks of the Nullagine Series, hence its geological age can only be defined within certain limits. The granite is of importance in that it carries all the tin and tantalite veins of the district, the parent source of the detrital tin of Moolyella, Old Shaw, Cooglegong, and Wodgina. The rich quartz reefs of Boodalyerri, and some in the neighbourhood of Yandicoogina, occur in these rocks.

**DOLERITE, DIABASE, AND GABBRO DYKES.**—A series of greenstone dykes have invaded all the other strata below the Oakover Beds in the form of dykes, which run in long and approximately parallel lines, and in many cases form very conspicuous features in the landscape, owing principally to their black weathered summits, which stand out in bold relief.

The dykes, which are all basic compounds, belong to two different periods. The newer basic dykes have a general north-east and south-west strike, and are often continuous for many miles. In many portions of the Goldfield the regular continuity of the system of dykes has been interrupted by faults, though no cases came under observation in which the horizontal shifting appeared to be very great. No very satisfactory evidence as to the age of these newer dykes has been obtained, though the Nullagine Series in the vicinity of the township of that name is pierced by them, clearly indicating that their age is post-Nullagine.

The older series of dykes have a general trend which is approximately at right angles to that of the newer system. Like the newer dykes they are all basic compounds, and in many cases they have been more or less crushed and sheared into schistose greenstones. Owing to the marked features which many of the dykes exhibit on the surface, they have proved of considerable value in working out the geological structure of the district in at least two of the mining centres.

## ECONOMIC GEOLOGY

The Pilbara Goldfield contains several gold and tin-bearing areas, scattered over different portions of the district. Economically, the auriferous deposits have proved up to the present to be the most important.

**GOLD.**—The geographical position of the various gold-mining centres shows a zonal development of the auriferous deposits.

From the result of the field observations, it appears that the auriferous deposits of the Pilbara Goldfield may be divided into six main and distinct groups, viz. :—

- (a) Lalla Rookh ;
- (b) North Pole, Talga Talga, Bamboo ;

- (c) Marble Bar, Warrawoona, Yandicoogina, Mt. Elsie, Boodalyerri;
- (d) Nullagine, 20-mile Sandy, Mosquito Creek;
- (e) Tambourah, Western Shaw; and
- (f) North Shaw.

The length of the Lalla Rookh Belt has not yet been defined, but it does not appear to be less than 30 or 40 miles. The North Pole, Talga Talga, and Bamboo Belt is 50 miles in length. The Marble Bar, Warrawoona, Yandicoogina, Mt. Elsie, and Boodalyerri Belt has a proved extent of about 80 miles. The Nullagine, Middle, and Sandy Creek zone is known to extend for a distance of at least 40 miles, and there are strong geological reasons for the belief that it continues much farther to the east, and may possibly cross the upper reaches of the Oakover River. The Tambourah and Western Shaw Belt has not as yet been accurately defined, but it does not appear to be less than about 30 miles in length, whilst that of the North Shaw has only been proved to extend for a few miles.

The general direction of these auriferous belts almost everywhere coincides with the strike of the schists, which, with one or two exceptions, invariably form the matrices of the gold-bearing reefs. The prevailing dip of the belts coincides with the general trend of the main structural features of the district. Their width naturally varies, and in the three most northerly zones, the width cannot be defined owing to the fact that one of the boundaries is invariably marked by a powerful fault, which throws down the newer beds against the schists.

Quartz reefs occur in great abundance all through the schistose rocks, as well as to a more limited extent in the areas occupied by the granitic rocks. The quartz reefs are of two distinct types, viz., white quartz reefs and laminated quartz and jasper veins, approaching very closely the hematite-bearing quartzites (?), which invariably form a conspicuous feature in most of the goldfields of the State. Some of the laminated quartz veins range from almost pure quartz, through banded jaspers, with crystals of magnetite, to bands appearing to the eye to be virtually pure hematite. Some of these—notably those in the Lalla Rookh Belt—could be readily concentrated to high-grade ores, which, under suitable conditions, might be turned to profitable account as sources of iron ore. The quartz reefs, of what may be called the massive type, occur plentifully in both the schists and the granites. They invariably occur along the planes of foliation (? bedding) of the schists, or, at any rate, cut them at a low angle.

The auriferous reefs cannot be said to be long, and are, as a rule, small, though they occasionally swell out into large lenticular masses. Some of the reefs have been traced along the outcrop for over 2000 feet, and have swelled out to masses measuring about 15 feet across.

The following table shows the gold yield from the different mining centres of the Pilbara Goldfield up to the close of 1905 :—

*Table showing the Gold Yield of the various Mining Centres of the Pilbara Goldfield up to the end of 1905.*

Group.	Mining Centre.	Ore Crushed.	Gold therefrom.	Rate per Ton.	Total.		Average Rate per Ton.
					Ore Crushed.	Gold therefrom.	
		Tons.	Ozs.	Ozs.	Tons.	Ozs.	Ozs.
(a.)	Lalla Rookh . . . Ore . .	6,532'50	7,547'84	1'15			
					6,532'50	7,547'84	1'15
(b.)	North Pole . . . Ore . .	416'00	277'02	'66			
	Talga Talga . . . Ore . .	779'15	1,496'23	1'92			
	Do. . . Alluvial . .	..	50'26	..			
	Do. . . Dollied . .	..	152'82	..			
	Bamboo . . . Ore . .	10,791'25	17,519'49	1'62			
	Do. . . Dollied . .	..	119'70	..			
					11,986'40	a 19,292'74	1'61
(c.)	Marble Bar . . . Ore . .	8,941'31	15,210'32	1'70			
	Do. . . Dollied . .	..	135'34	..			
	Wyman's Well . . Ore . .	233'40	734'69	3'14			
	Do. . . Dollied . .	..	11'32	..			
	Warrawoona . . Ore . .	7,155'76	15,552'90	2'17			
	Do. . . Alluvial . .	..	44'30	..			
	Do. . . Dollied . .	..	335'73	..			
	Yandicoogina . . Ore . .	2,686'25	5,521'47	2'05			
	Do. . . Dollied . .	..	356'88	..			
	Mount Elsie . . Ore . .	508'25	1,560'28	3'07			
	Boodalyerri . . Ore . .	120'25	587'86	4'88			
	Do. . . Dollied . .	..	148'85	..			
					19,645'22	b 39,167'52	1'99
(d.)	Nullagine . . . Ore . .	13,662'40	20,713'02	1'51			
	Do. . . Alluvial . .	..	104'70	..			
	Do. . . Dollied . .	..	81'93	..			
	20-mile Sandy . . Ore . .	2,282'60	5,802'59	2'54			
	Mosquito Creek . Ore . .	5,779'99	9,156'47	1'58			
	Do. . . Dollied . .	..	166'47	..			
	Sundry Parcels . Ore . .	38'50	2,393'22	6'21			
	Alluvial . . . . .	..	1,529'32	..			
	Notices of Purchase . Alluvial .	..	2,161'24	..			
	Do. do. . . Dollied . .	..	22'50	..			
					21,763'49	c 38,065'30	1'74
(e.)	Tambourah . . . Ore . .	2,077'75	2,536'88	1'22			
	Do. . . Dollied . .	..	64'65	..			
	Western Shaw . . Ore . .	1,221'00	930'73	'76			
	Do. . . Dollied . .	..	4'77	..			
					3,298'75	d 3,467'61	1'05
(f.)	North Shaw . . . Ore . .	351'45	674'72	1'91			
	Do. . . Alluvial . .	..	7'53	..			
	Do. . . Dollied . .	..	567'06	..			
	Shark's . . . Ore . .	6'00	33'00	5'50			
	Do. . . Alluvial . .	..	145'08	..			
	Do. . . Dollied . .	..	15'17	..			
	Shaw River . . . Ore . .	101'00	49'63	'49			
	Breen's Find . . Ore . .	14'00	66'82	4'77			
					472'45	e 824'17	1'74
	Sundry parcels reported at Marble Bar. <sup>1</sup> . Ore . .	237'95	1,099'71	4'62			
	Do. do. do. . Alluvial . .	..	4,109'29	..			
	Notices of Purchases reported at Marble Bar . Alluvial .	..	1,435'44	..			
	Do. do. do. . Dollied . .	..	202'52	..			
					237'95	f 1,099'71	4'62
	Total . . . . .	..	..	..	63,936'76	g 109,464'89	1'71

<sup>1</sup> Localities not specified. a Not including 50'26 ozs. alluvial and 272'52 ozs. dollied. b Not including 44'30 ozs. alluvial and 988'12 ozs. dollied. c Not including 3,795'26 ozs. alluvial and 270'90 ozs. dollied. d Not including 69'42 ozs. dollied. e Not including 152'61 ozs. alluvial and 582'23 ozs. dollied. f Not including 5,544'73 ozs. alluvial and 202'52 ozs. dollied. g Not including 9,587'16 ozs. alluvial and 2,385'71 ozs. dollied.



The value of any reef being in a large measure influenced by its richness and its quantity, *i.e.* the thickness, length, and breadth of the shoots of gold, wherever possible, observations were made tending to throw any light thereon. So far as may be judged from the official returns from the various properties, it appears that the shoots of gold are rich, whilst the condition of the various workings implies that they are short.

The auriferous ores as a whole are of such a mineralogical character as render them readily amenable to battery amalgamation and cyanidation.

In addition to the gold derived from quartz reefs, the conglomerates at the base of the Nullagine Series have in two localities—Nullagine and Just-in-Time—been mined, and the gold, as set forth in the tables below, obtained. It is noteworthy that the base of the series has only proved auriferous in those places where it lies upon that portion of the underlying formation which carries auriferous quartz reefs.

At Nullagine the auriferous strata occur through a thickness of about 300 feet of grits, sandstones, and conglomerate, which form the lowest portion of the series. The auriferous conglomerate is of sedimentary origin, and is made up of rounded and subangular fragments of the underlying strata. Those portions of the strata which have proved to be gold-bearing are those which are largely impregnated with the oxides and sulphides of iron, and which lie between a well-marked fault and a greenstone dyke. Mining operations have, up to the present time, been confined exclusively to the oxidised zone of the conglomerate and to very limited and shallow depths. The available evidence regarding the origin of the gold seems to indicate that it is a secondary and not an original constituent of the conglomerate; and owed its introduction to the percolation of mineral-bearing solutions down the most porous portions of the conglomerate, this condition being facilitated by the downward inclination of the bedrock, and possibly accentuated in part by the folding which the strata have undergone. Numerous dryblowers have been at work for a number of years over that portion of the conglomerate from which the crushings have been obtained, and have acquired a considerable quantity of gold, of which the published figures afford no clue. In all probability one-half of the "alluvial" gold from Nullagine may be legitimately claimed to have been derived from the escarpment of the conglomerate.

At Just-in-Time, 8 miles to the south of Marble Bar, another auriferous conglomerate at the base of the series has been worked. In many respects the auriferous conglomerate resembles the ferruginous bands as developed at Nullagine, and varies in thickness from an inch up to 5 feet in thickness. Certain portions of it contain a sufficient quantity of iron oxides to give quite a distinctive character to the rock. The auriferous conglomerate of Just-in-Time is, however, not of any very great horizontal extent,

nor does it appear to penetrate to any considerable depth. As has been the case at Nullagine, the sloping ground at the foot of the escarpment has yielded considerable quantities of gold to the dryblowers, but, unfortunately, it did not appear to have been possible to keep a separate record thereof. Most of the gold obtained in this way owed its origin to the disintegration of the conglomerate.

*Table showing the Yield of the Auriferous Conglomerates of the Pilbara Goldfield.*

Mining Centre.	Ore Crushed.	Gold therefrom.	Rate per Ton.
	Tons.	Ozs.	Ozs.
Nullagine . . . . .	5,167·00	3,217·29	·62
Just-in-Time . . . . .	60·00	47·30	·78
Total . . . . .	5,227·00	3,264·59	·62

Whilst the various tables above give fairly reliable data as to the production of the reefs and conglomerates, the amount of alluvial gold from Pilbara can only be roughly approximated. The large nuggets for which the district is famed are of distinctly local origin, and are derived from the disintegration of quartz veins.

The auriferous zones of the Pilbara Goldfield resemble, in many important respects, the gold belts of the Murchison and the Eastern Goldfields of the State. Not only are the various rocks similar in character, but they may possibly be of the same geological age, whilst there is also the same linear persistence of the quartz reefs parallel to the general trend of the dominant structural features of the auriferous series.

TIN.—The tin deposits of the Pilbara Field, which have yielded 2053·52 tons of tin, valued at £140,689, are, with one or two exceptions, all of detrital origin. The deposits extend over a wide extent of country, covering some hundreds of square miles, and have been actively exploited at several centres, many miles apart.

Lode tin is known to occur in the granite area of Moolyella; but, owing to the low percentage of cassiterite in the pegmatitic granite veins, it has not yet been worked. The bulk of the tin from this centre has been obtained from the alluvial deposits which form the existing valleys; they have, however, not been found to attain any great thickness, though their width, in some places, exceeds 10 chains. In addition to the alluvial deposits, a large quantity of residual tin, *i.e.* ore derived from the decomposition of the tin-bearing pegmatites, *in situ*, occurs, and has been responsible for no small portion of the yield from Moolyella.

At Wodgina, which was discovered in 1902, the tin occurs in

veins of pegmatitic granite, which penetrate a series of sedimentary and bedded igneous rocks, occurring along its flanks. Wherever these veins have been opened up, it is found that the tin occurs on either wall, in a band consisting of mica and tourmaline in varying proportions. The bed of the ravines, and the slopes on the hill-sides, carry detrital and residual tin. The tin-bearing pegmatites are numerous, though it yet remains to be proved whether they can be profitably mined. This centre bids fair to rise in importance as a tin-producer.

**TANTALUM.**—Tantalum-bearing ores have been worked at Wodgina, and up to the end of 1905, 70·95 tons, valued at £8925, have been raised. In addition to the alluvial and residual deposits, which have yielded by far the larger quantity of tantalite, the mineral has been found occurring in pieces of large size in one of the pegmatite veins which traverse the field. Much of the detrital tantalite results from the disintegration of the rich shoot in this vein. Having due regard to the uses to which the metal tantalum can be put, the discoveries at Wodgina are of importance, and there seem every reason for believing that the area over which the mineral occurs will be extended.

It may be noticed in this connection that the various tantalates and niobates of the rare earths, which exhibit marked radio-active properties, have been found to occur as primary constituents of such pegmatites as are met with at Wodgina; hence it is highly probable that careful search in the district may result in the discovery of the radio-active minerals, Thorianite, Fergussonite, Samarskite, Euxenite, &c.

*Table showing the Tin and Tantalite Yield of the Pilbara Goldfield up to the end of 1905.*

Mining Centre.	Tin.		Tantalite.	
	Ore Raised.	Value thereof.	Ore Raised.	Value thereof.
	Tons.	£	Tons.	£
Cooglegong . . .	760·35	52,179	...	...
Moolyella . . .	1,261·72	86,048	...	...
Old Shaw . . .	145·34	10,530	...	...
Wodgina . . .	31·45	2,462	70·95	8,925
Total . . .	2,198·86	151,219	70·95	8,925

**DIAMONDS.**—The occurrence of small diamonds in the auriferous conglomerate at the base of the series at Nullagine has been noticed. At the present time, however, the interest is rather more scientific than commercial.

**IRON.**—Iron ores occur plentifully throughout the district. Many of those laminated quartz and jasper veins, notably in the Lalla Rookh zone, pass gradually into bands of what appear to the



eye to be virtually pure hematite. Some of these deposits could readily be concentrated to high-grade ores. At present these are of course entirely beyond the reach of commercial enterprise, but, under more favourable conditions, there is little doubt but that some of them might be turned to profitable account as sources of iron ore.

**TUNGSTEN.**—An ore of tungsten, scheelite (tungstate of lime), has been met with in the lode occurring in the Ard Patrick Mine at Mosquito Creek. Two samples of this have been assayed in the Survey Laboratory, with the following results:—

- (a) 50·93 per cent. of tungstic acid ;
- (b) 45·1 per cent. of tungstic acid and 1 dwt. 15 grs. of gold per ton.

In both these samples, the comparatively low percentage is due to the admixture of a good deal of quartz with the scheelite. The mode of occurrence of the scheelite in the Ard Patrick seems practically identical with that in the Fraser's Mine, Southern Cross; Lindsay's Mine, Coolgardie; and the Record Mine at Norseman. Scheelite is marketable, and in this case it is merely a question of concentration, provided the ore occurs in such quantities to make it worth the expense.

**ASBESTOS.**—Asbestos is known from the district in the vicinity of Tambourah, but in what quantity or in what mode it occurs there is no definite information, as no official inspection of the locality has as yet been found possible. So far as may be judged from the specimens [1010, 6212] at present in the Geological Survey Museum, the asbestos from Tambourah turns out to be fibrous chrysotile, identical with the Canadian mineral which is so much valued. The Tambourah asbestos, unlike most of the Australian mineral, has not the great defect of a low tensile strength, and in all the points—infusibility, softness, flexibility, fineness, and the ease with which the fibres can be separated—is well above the average.

**LEAD.**—The occurrence of argentiferous lead ores is known from the neighbourhood of Tambourah, through specimens which have been sent in to the office for assay. No particulars regarding the ores are known to the Department than are to be gathered from the results of the official assays, which are as follows:—

Description of Ore.	Lead per Cent.	Gold. Ozs. per Ton.	Silver. Ozs. per Ton.
Cerussite, &c. . . .	43·3	·736	22·69
„ . . . .	60·1	<i>Nil</i>	88·31
Galena . . . .	64·5	Trace	68·75
„ . . . .	68·8	Trace	75·07

## FUTURE PROSPECTS

The attempt to forecast the future of any mining district is at all times a difficult matter, but more especially is it the case in any field where most of the mines are abandoned, full of water, or otherwise inaccessible.

A correct judgment of the future capabilities of gold mining in Pilbara cannot, however, be formed if the fact is ignored that the auriferous quartz reefs are of that somewhat irregular type described in the pages of various reports. The reefs, however, give every indication of being permanent, whilst the average returns from the mines up to the close of 1905, have been, so far as may be judged by the figures furnished to the Mines Department, high, viz., 1.71 ozs. per ton of ore milled.

Far less genuine and judicious prospecting appeared to have been done than the prospects of the field seem to warrant, for though the auriferous quartz reefs are irregular, they are numerous, and the wide-spread occurrence of quartz reefs, throughout the different zones in the district indicate perfectly clearly that the capabilities of the field, despite its relatively long existence, are by no means exhausted.

It seems, therefore, that the past history of gold mining in the district will be its future history, viz., the discovery of short, rich shoots in veins and reefs of the type described in the three reports, the exploitation of which seem best suited to the operations of small companies.

The auriferous conglomerates of Nullagine and Just-in-Time occurring at the base of such an extensive formation, though when looked at from a broad point of view, low-grade local deposits are of such a nature as would seem to encourage efforts in the direction of carefully prospecting other parts of the basal members of the series in the district. The area over which the formation extends is more or less accurately delineated upon the geological map of the field, which forms the frontispiece to this report, and should be of some assistance in this connection.

The very large area of intrusive granite in which tin has actually been worked in at least four localities, many miles apart, should encourage careful and judicious prospecting, more especially in those portions along the margin of the mass where it sends out veins into the surrounding rocks, and if intelligently carried out there is every probability that other tin mining centres will be discovered.

If prospecting and mining operations are carried out in the Pilbara Goldfield with due regard to the prevailing geological conditions, it may be confidently asserted that the district will continue to be a gold, tin, and tantalite producer.

A. GIBB MAITLAND,

Government Geologist.

## APPENDIX II

*Descriptive Register of Specimens from the Pilbara Goldfield (referred to in this portion of the report).*

Registered No. of Specimen.	Registered No. of Microscopic Section.	Name.	Locality.
6452	658	Quartzite . . . . .	Wodgina
6460	...	Quartzite (iron-bearing)	Wodgina
6496	687	Conglomerate (auriferous)	Just-in-Time
6497	688	Conglomerate . . . . .	Just-in-Time
6461	663	Mica slate . . . . .	Wodgina
6453	659	Greenstone . . . . .	Wodgina
6486	679	Greenstone . . . . .	South-east angle of Corunna, G.M.L. 272
6491	684	Greenstone . . . . .	
6492	685	Greenstone . . . . .	Main shaft, Tambourah King, G.M.L. 252
6498	689	Vesicular andesite . . . . .	Just-in-Time
6499	690	Andesite . . . . .	Just-in-Time
6462	664	Hornblende slate . . . . .	Wodgina
6485	678	Hornblende schist . . . . .	Tambourah
6489	682	Greenstone schist . . . . .	Government Well, Tambourah
6487	680	Granite . . . . .	Arrastra, Tambourah Creek
6488	681	Granitic schist . . . . .	West of G.M.L. 274, Tambourah
6490	683	Granitic schist . . . . .	Western Chief Lease, G.M.L. 568, Tambourah
6466	...	Pegmatite . . . . .	Bull's Lode Claim, Wodgina
6479	672	Pegmatite granite . . . . .	Main Lode, Stannum Mine, M.L. 77, Stannum Group, Wodgina
6474	669	Porphyry . . . . .	Main Mass, Stannum, M.L. 77, Wodgina
6475	670	Porphyry . . . . .	Main Mass, Stannum, M.L. 77, Wodgina
6476	671	Porphyry . . . . .	Dyke in Greenstone, Stannum Group, Wodgina
6480	673	Felspar porphyry . . . . .	Dyke in Greenstone, Stannum Group, Wodgina
6455	661	Tourmaline rock . . . . .	M.L. 89, Wodgina
6464	665	Tourmaline rock . . . . .	Commonwealth, M.L. 85, Wodgina
6454	660	Blue quartz (quartz, lepidolite, and orthoclase)	M.L. 89, Wodgina
6456	...	Tourmaline in quartz . . . . .	Wodgina
6457	662	Manganotantalite (lode) . . . . .	M.L. 86, Wodgina
6458	...	Manganotantalite (lode) . . . . .	M.L. 86, Wodgina
6470	...	Manganotantalite (lode) . . . . .	Eadie's Claim, Wodgina
6459	...	Manganotantalite (detrital)	M.L. 86, Wodgina
6463	...	Cassiterite (lode) . . . . .	Main Lode, Cassiterite Mine, M.L. 84, Wodgina
6465	...	Cassiterite (lode) . . . . .	M.L. 94, Wodgina
6468	...	Cassiterite (lode) . . . . .	M.L. 84, Wodgina
6471	...	Cassiterite (lode) . . . . .	Comet Mine, M.L. 80, Stannum Group, Wodgina
6472	...	Cassiterite (lode) . . . . .	Stannum North Mine, M.L. 79, Stannum Group, Wodgina
6477	...	Cassiterite (lode) . . . . .	Stannum Mine, M.L. 77, Stannum Group, Wodgina
6494	...	Garnet . . . . .	Gadolinite Lease, Cooglegong
6495	...	Gadolinite . . . . .	Cooglegong
6467	...	Chloropal (var. pinguite) . . . . .	Cassiterite Mine, M.L. 84, Wodgina
6478	...	Tourmaline (blue) . . . . .	Tin Lode, Stannum Mine, M.L. 77, Stannum Group, Wodgina





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APPENDIX III.

REPORT

ON THE

PILBARA AND WEST PILBARA  
GOLDFIELDS

(With Special Reference to the Proposed Railway  
from the Coast to Marble Bar).

BY

A. MONTGOMERY, M.A., F.G.S.,  
STATE MINING ENGINEER.



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## Report on the Pilbara and West Pilbara Goldfields, with special reference to the proposed Railway from the Coast to Marble Bar.

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Office of the State Mining Engineer,  
Perth, 8th August, 1907.

*The Secretary for Mines, Perth, W.A.*

I have the honour to transmit to you hereunder, for the information of the Hon. the Minister for Mines, a report on the present condition of the Gold and Mineral fields of the Pilbara and West Pilbara Goldfields, with special reference to the projected railway from Port Hedland or other port on the coast to Marble Bar, or some other convenient terminus in the central portion of the Pilbara Goldfield.

I had the honour to accompany the Hon. the Minister for Mines on his recent journey through these fields. Leaving Perth on April 21st, we arrived at Port Hedland on 27th of the same month, leaving next day for Marble Bar, which was reached on May 1st. We then visited the Moolyella, Nullagine, Mosquito Creek, Warrawoona, and Mt. Edgar districts in the order named, returning to Marble Bar on May 11th. Leaving next day, we then went by North Shaw, Cooglegong, and Tambourah, to Wodgina, where over two days were spent. Leaving Wodgina on May 19th we went by Pilbara, Station Peak, and Mallina to Whim Creek, myself diverging from the route of the rest of the party to visit the Croydon and Towrannah fields. Two days were spent at Whim Creek and Balla Balla, and the party left for Roebourne on May 25th arriving on May 26th. The mines in the vicinity of Roebourne were visited between this date and the departure of the steamer on June 1st, which brought us back to Perth on June 7th. On following out this route on the map it will be seen that the trip was of the most flying character, and that no minute examination could be made of the country or of the mines, still it was sufficient to allow a good grasp to be obtained of the general position of affairs as regards the mining industry, and to become seized of the most important points to be considered in dealing with the railway proposition.

The examination of the country was greatly facilitated by the fact that it had already been minutely gone over by the Government Geologist, whose three reports, in Geological Survey Bulletins Nos.

15, 20, and 23, illustrated as they are with numerous maps and figures, give a very complete description of the structure and mines of the Pilbara Goldfield, and must form, for years to come, the basis of every general description of this region. The present report continually refers to these Bulletins, and contains much repetition of matter already published in them, and they should be constantly in the hands of anyone perusing it, for reference to the fuller descriptions and the maps and tabulated statistics given therein. Unfortunately the Government Geologist's report on the West Pilbara Goldfield has not yet been entirely completed and published, so that there is not the same information available with regard to it, but I have availed myself fully of the portions which have already appeared in the daily Press relative to some of the mining centres when compiling my description of these.

*Topography.*—The coast-line of the Pilbara Goldfields runs in an east-north-easterly direction, being thus nearly at right angles to the portion of the coast in the vicinity of Perth, and it is therefore necessary to travel in a more or less northerly direction to reach the coast by the nearest route from almost any of the mining centres. The general east and west orientation of these fields is often necessary to be recalled to the minds of those who are accustomed to the more or less north and south trend of the auriferous belts in our Central and Eastern Goldfields.

Along the coast the country is mostly composed of extensive sand-plains in the Pilbara Field, but in the West Pilbara these are smaller, and numerous rocky hills come right to the sea. For some miles inland from the coast these plains are usually composed of beds of detrital material of comparatively recent geological age, but they do not appear to be of great depth. The soil is a loamy sand, which on roads rapidly becomes worked up into a mobile condition, causing traction of vehicles to be heavy and difficult, and very tiresome to men or animals walking over it. Further inland the plains still continue for many miles, but are now found to be composed of granite, covered with only thin coatings of superficial drift, and they bear, distributed freely over them, numerous rocky hills and small ranges which stand up very abruptly from the plains like islands from a sea. Near Roebourne and to the north of Balla Balla these ranges run right out to the coast, and the plain country is not so much in evidence as it is to the south and south-east from Port Hedland. In this latter part of the district the great granite plain runs inland for about 60 miles before it meets any large area of hilly country. The plain is rising gradually as we get inland, but everywhere preserves its sea-like appearance, and there is no doubt in my mind that it represents a great plain of marine denudation, wherein the easily weathered main granite rock has been worn down by marine action to a general even level, above which the harder portions have been left standing up, at first as actual islands, and later on as steep hills. These granite plains can be traced



inland to Yandicoogina on the north side of the Warrawoona Range, and by the flats of the Upper Turner River and Shaw Tinfields to Corunna Downs on the south side of the same Range. Indeed, so far as I saw the country, the granite country coloured pink in the geological map of the Pilbara Goldfield in *Geological Survey Bulletin* No. 23 is mostly all portion of this great marine plain, though more and more studded over, as we come inland, with rough abrupt hills of outstanding harder rocks. The general continuity of the granite plains is of the greatest importance in considering the question of railway routes, as they afford very easy country for railway construction. The soil on the granite country is, however, very sandy, making the roads over it very heavy for horse traction, and thus the ground which is specially favourable for railway making is anything but suitable for cartage roads without much expense in forming and gravelling these.

The geological map above referred to shows several areas of green colour, which are composed of very ancient metamorphic and greenstone schists, and all of which are regions of rugged rocky hills and ranges. One important outlying island of this sort forms the Wodgina Tinfield, which is very steep hilly country, and others of similar character are seen to the north of it. The main green area shown on the map is a very extensive one, and represents very rugged country standing up high above the surrounding granite plains, but still with the same island-like appearance as the smaller one at Wodgina. The green areas therefore represent country which is necessarily difficult of penetration by railways. It, however, also represents the home of the auriferous and metalliferous reefs and therefore is of the greatest importance from a mining point of view. It is readily seen from the map that all the gold-mining centres are in the green areas with the exception of those between Nullagine and Mosquito Creek, which are in another ancient schist and slate formation. The geological map is therefore of great service in indicating by its colouring not only the geological structure of the country, but incidentally also the distribution of the minerals and the principal facts of the topography.

The Pilbara Goldfields are traversed by a large number of rivers. During the exceedingly heavy rains accompanying the cyclonic storms which at times burst over the district these streams often become wide and deep rivers, carrying enormous volumes of water, but in ordinary weather there is water in them only in detached pools sometimes long distances apart. The beds crossing the plains are wide and shallow, and carry great quantities of shingle and sand. The forests of the region, such as they are, are almost entirely confined to these river beds and valleys, and consist of rather sparse and somewhat stunted and gnarled trees of river-gum, black-heart gum, bloodwood, and kadgebut, which furnish such firewood and mining timber as is available.

The plains and less rocky hills are plentifully covered with spinifex grasses of several varieties, which with interstitial grasses afford good pasture for stock, nearly the whole of the flatter country being in consequence taken up under pastoral leases as sheep and cattle stations. The excellent condition of the stock is a great revelation of the pastoral possibilities of this country to those who have not previously known of the value of the spinifex as fodder. Stocking of the plains with sheep seems to be proceeding very rapidly, the pastoral industry having made great advances of recent years.

*Geological Structure.*—No description of these mining fields can dispense with some reference to their geological structure, and though this has been described in detail in the Government Geologist's Bulletins, and is referred to in the present report in the accounts given of the various mining districts, it seems advisable at this stage to present a short summary of the principal geological features.

The oldest rocks in the Pilbara Goldfields are those coloured green on the geological map in *Bulletin* No. 23, which have been termed the Warrawoona Series by the Government Geologist. They are highly metamorphic schists and more or less schistose igneous rocks, which have been so highly plicated that they are now found almost always dipping at very high angles, and much faulted. They occupy a large area in the centre of the Pilbara Field, and are the principal home of the auriferous and eupriferous lodes. The lodes very generally lie more or less parallel to the foliation of the schists, which varies very greatly in strike in different parts of the area. The strike very frequently is approximately parallel with the contact of the schists with the granite surrounding them, a fact of considerable significance from the point of view of structural geology, but not worth dwelling upon for our present purpose. This series of rocks is probably of much the same age as the greenstones and dioritic schists of the Eastern Goldfields of Western Australia, to which its igneous members exhibit great similarity in composition and appearance.

The next series of rocks in point of age are those shown in yellowish-brown colour on the Geological map, occupying a large area from Nullagine eastward to the Oakover River, and termed by the Government Geologist the Mosquito Creek Beds. There is some evidence that they are younger than the Warrawoona series, and though highly plicated they do not seem to have suffered such intense pressure and metamorphic action as the older rocks, and are therefore much less crystalline. They also contain auriferous reefs which have a tendency to conform generally in strike with the strata enclosing them.

The great granite formation which is far the most extensive of any in Western Australia not only in the Pilbara fields but also

in the goldfields south of them, is shown in pink colour on the Geological map. It is clearly younger than both the preceding series of rocks, through which it intrudes frequently. Quartz reefs are numerous in it, but except in close proximity to the greenstones it is notable that they have rarely, if ever, been found to contain payable gold. In some of the fields it is noteworthy that the auriferous reefs traverse both greenstone and granite country indiscriminately, showing that they were formed subsequently to the main masses of the granite. The granite is frequently stanniferous, being often traversed by pegmatite dykes or veins carrying tin ores.

All these older rocks are traversed by numerous dykes of igneous origin, and of several different varieties and ages—porphyries, felsites, diorites, diabases, and gabbros. The diabase dykes often form rugged black-topped rocky ranges running for many miles across the country, and may have some connection with the lava sheets of the Nullagine series to be mentioned presently. No important connection has yet been made out between any of these igneous rocks and the occurrences of minerals in the districts traversed by them, but they point to the general fact that the older rocks of the district have been repeatedly subjected to igneous intrusions, which would doubtless have their usual concomitant of hydrothermal activity, a condition commonly held to be favourable for the formation of ore-bearing lodes. A stronger and much more direct evidence of intense hydrothermal action is afforded by another set of dyke-like rocks very common throughout the Pilbara fields, and also well known further south in the Central and Eastern Goldfields. These are the jasperoid quartzites seen in nearly all the geological maps of the Pilbara fields, and particularly prominent in the district between Mt. Magnet and Cue in the Murchison field. The celebrated "Marble Bar" on the Coongan River is one of the best known of these. They are very common, and are frequently in very close proximity to the auriferous reefs, with which there is some reason to suppose they may often be genetically connected. They are essentially of lode character, being most probably zones of fracture and shearing along which hydrothermal and pneumatolytic action has caused extensive deposition of silica and oxide of iron in veins and strings with simultaneous removal of most of the more soluble constituents of the original material and replacement of them by silica and iron oxides. They are very commonly found throughout the Pilbara field close to the contact between the Warrawoona series of old rocks and the intrusive granites, suggesting that they are often contact lodes, but numbers are also found traversing the greenstone schists when no granite is visible in the near vicinity. These "jasper bars" have not been found in the Pilbara fields to possess any economic importance, but they have significance as showing that in the districts where they occur the agencies have been strongly at work to which are usually ascribed the formation of valuable lodes.



All the rocks hitherto mentioned, including the lodes and jasper bars, but excepting some of the newer basic dykes, are of very great geological antiquity, probably at any rate pre-Cambrian, if not entirely Archaean. We have now to mention, however, a very much younger series of beds which cover large areas of both the Pilbara fields, and which have been named the Nullagine Series by the Government Geologist. These are strata of conglomerates, grits, sandstones, and shales interbedded and overlaid by volcanic lavas and fragmentary deposits, which lie more or less horizontally on the denuded upturned edges of the older strata. They themselves have been subjected to slight bending through earth movements, but rarely show any considerable plication. They are made up of detritus of the older formations, and contain fragments of the auriferous veins belonging to these, showing them to be younger than the date of formation of the auriferous lodes. Gold has been found in some of the conglomerates of this series at Nullagine and Just-in-Time under circumstances similar to those of its occurrence in the "banket" reefs of South Africa, and the copper-bearing lode of the Whim Well Company, at Whim Creek, is also very probably in strata of the same formation. Apart from these metalliferous beds this series of rocks does not appear to be a mineral-bearing one. In the Geological Survey Bulletins above-mentioned the age ascribed to the Nullagine beds is tentatively put down as Cambrian, but in his recent address to the Australasian Association for the advancement of Science, at Adelaide in January last, the Government Geologist has altered this to Devonian.

The geological map shows two or three small patches of probably still younger rocks near the Oakover River, consisting of sandstones, limestones, and cherts of uncertain age, and which are not known to be of any economic importance. Their occurrence so far inland may be of some importance in enabling some realisation to be arrived at of the conditions under which the vast coastal plain might have been formed by marine action.

The coastal formation of sandstones, incoherent sands, and limestones is probably of rather recent geological age, but portions of it may date back to Tertiary or even Cretaceous times. It is not of importance for our present investigation.

In the detailed description of the various fields hereunder, further reference is made to the geological structure of each, as seems necessary to explain the mode of occurrence of the mineral deposits.

#### DESCRIPTION OF THE MINING DISTRICTS.

Before proceeding further with discussion of the question of railway routes it will be of advantage to describe the various mining centres in some detail, after which we shall be in a better position to discuss the question of

how best to improve their working facilities by removing the disabilities which have hitherto stood so much in the way of the development of these goldfields, and which will be best understood after consideration of the conditions of the individual cases separately. In the following notes the districts are not described in the actual order in which they were visited, but as they would be traversed by a person landing at Roebourne and going eastward through the fields to Mosquito Creek.

#### ROEBOURNE DISTRICT.

The country round Roebourne has long been known to carry lodes with gold, copper, and lead in them, and a little mining work has been done from time to time for many years past, but it is only lately that there has been any considerable revival of prospecting in this very promising district. This is somewhat remarkable, seeing that owing to its proximity to the coast we should expect that there would not be the serious difficulties in regard of cost of transport of timber, machinery, and supplies that have so greatly hampered the development of mines inland, and consequently that there would have been steady progress in mining. The district seems, however, never to have attracted much attention from the mining public outside and to have been left mostly to the enterprise of local residents to develop. Notwithstanding its proximity to the coast it has not been by any means an easily accessible place, as goods arriving by steamer had to be transhipped in Cossack Roads to lighters, brought by them up a tidal creek to Cossack jetty, and thence carried by horse tramway to Roebourne. The recent construction of a deep-water jetty at Point Sampson has now enabled vessels to discharge on to it, but as there is no practicable road for wheeled traffic from Point Sampson to Roebourne it is still necessary to send goods by lighters to Cossack as before. The construction of a tramway from Point Sampson jetty to join the Roebourne-Cossack tramway is very urgently required, and would be a very great boon to the district. Steamers are able to lie alongside Point Sampson jetty and take in and discharge cargo there at any time of the tide and in most weathers, there being usually not more than ten or twelve days in each year—according to the information given to me—on which the sea is so rough as to preclude their remaining alongside. The extension of the tramway would therefore enable rapid despatch to be given both in exporting and importing goods, doing away with the delays and costs of lightering from Cossack. At present it costs 21s. a ton to carry copper ore, in bags, from the tramway shed at Roebourne *via* Cossack by tramway and lighter and put it on the coastal steamers in Cossack Roads. Such serious shipping and landing charges in addition to a coastal freight of 20s. a ton to or from Fremantle, constitute a formidable portion of the costs of realising ore and importing mining supplies.

In the immediate vicinity of the town of Roebourne the country is mostly massive diorite of a coarsely crystalline structure, but which changes to a somewhat fine-grained variety of the same rock to the south and west of the town in the vicinity of the copper mines. There are also occasional intrusions of felsite. Further west the country is principally laminated schist with high angles of dip which may be diorite schist or perhaps a metamorphic schist, probably of Archaean age, especially well seen at Nichol Bay. To the east and south-east of Roebourne granite is found, and is seen at intervals all along the road to Whim Creek, appearing to be the principal rock formation, but is broken in places by wide intrusions of the coarsely crystalline diorite, as at Sherlock Station and close to Whim Creek. Several large outcrops are seen in the district of hematitic jasperoid "bars" referred to in the above geological sketch. One very excellent sample is seen at the shore end of Point Sampson jetty, the outcrop of the bar running north-north-easterly in a nearly straight line for a long distance. Another great outcrop of the same sort forms the hills on the south-east side of the gold workings at Weerianna, and another is seen to the north of the Carlow Castle mine.

#### LEAD MINES.

*Brother's United M.L. No. 67.*—About seven miles South of Roebourne and very close to the junction of the granite country with the diorite several mineral leases have been taken up or applied for, the principal one being the Brother's United M.L. 67. On this there is a long well defined reef running nearly due North and South, in hard crystalline diorite country, evidently a true fissure vein. It has an Easterly underlay, and is said to be from four to six feet wide in the workings from a shaft which has been sunk, but which was full of water at the time of my visit. The outcrop is very easily traceable as a distinct line of quartz, often several feet in width. The shaft is said to be 30 feet deep, and there has been a little driving done from it North and South on the course of the reef. The lode matter is principally quartz, but at the shaft and in some trenches South and North of it there is a good deal of galena and some blende in the stone, and near the surface considerable carbonate of zinc and a little green carbonate of copper. Mr. Woolcock, the owner of the lease, told me that he had had a bulk assay of the galena ore heap which returned 54 per cent. of lead, and that the assays in silver ran from four to six ounces to the ton, with a little gold. The ore, however, that I saw in the paddocks would require very careful picking to yield a marketable product, and most of it would require concentration by dressing machinery. Galena is seen in several cuts on the outcrop of the lode, the furthest North of them being a shallow shaft about 50 chains North of the main workings. I took a sample of the cleaner galena from the various cuts



while passing along the outcrop in order to ascertain approximately its average value in gold and silver, the sample returned—

	per cent.
Moisture	0.16
Silica, $\text{SiO}_2$	16.08
Alumina $\text{Al}_2\text{O}_3$	1.23
Iron, Fe	.85
Zinc, Zn	.61
Copper, Cu	.42
Lead, Pb	67.07
Sulphur, S	12.93
Oxygen, carbonic acid, O, $\text{CO}_2$ , etc.	.65
	<hr/> 100.00 <hr/>

Equal on the dry ore to—

	per cent.
Copper	0.42
Lead	67.17
Silver	3ozs. 18dwts. 10grs. per ton
Gold	trace

A sample of the Carbonate of Zinc ore was also analysed, giving—

	per cent.
Moisture	0.15
Silica, $\text{SiO}_2$	14.33
Alumina, $\text{Al}_2\text{O}_3$	1.90
Magnesia, $\text{MgO}$	.58
Lime, $\text{CaO}$	trace
Iron, Fe	1.25
Zinc, Zn	38.14
Copper, Cu	.25
Lead, Pb	3.51
Sulphur, S	1.00
Oxygen, carbonic acid, O, $\text{CO}_2$ , etc.	38.89
	<hr/> 100.00 <hr/>

The assay on the dry ore was—

	per cent.
Copper, Cu	0.25
Lead, Pb	3.51
Zinc, Zn	38.20
Silver, Ag	10dwts. 21grs. per ton
Gold, Au	22grs. per. ton

The Zinc is equal to—

	per cent.
Carbonate of Zinc, $\text{ZnCO}_3$	69.22
and	
Sulphide of Zinc, $\text{ZnS}$	3.04

From these analyses it is seen that the ore is poor in the precious metals.

Near the North workings a branch lode is seen to the Eastward, going off on a more North-Easterly course. A shaft has been sunk some 12 to 15 feet on this, but the ore did not seem to me to be at all promising.

Close to the North shaft the lode and enclosing diorite country are both penetrated by a more recent dyke of fine-grained basalt, about 10 inches thick, which however does not fault the quartz reef appreciably.

Though this lode contains some fair galena and may improve when opened up, it did not seem to me to be of very much promise, the low value of the galena in precious metals, the presence of considerable zinc, and the necessity for concentrating most of the ore being all against it. It certainly deserves more prospecting than it has yet had, in the hope that there may be richer shoots of ore in it, but there is not yet much encouragement to open out with permanent mining work. There is a good deal of water at rather shallow depth in the Southern workings, and Mr. Woolcock told me that he found the influx too great to be coped with by manual labour alone, so that even for proper prospecting a light steam pumping plant would be of much advantage.

#### COPPER MINES.

*Fortune M.L. No. 64, Aurora Australis M.L. 93 and Aurora Australis West, M.L. 94.*—These three lease applications are taken up on the lode formerly worked on gold mining leases 60 and 61 by the Glenroebourne Gold Mines. The Fortune is a small holding taking in a large quartz outcrop and the principal old workings, and the other two leases are East and West of it. The big quartz outcrop stands out prominently from the flat valley in which it occurs, and the reef has been traced a short distance North-East from it and for nearly a quarter of a mile to the South-West, part of this distance being, however, possibly on a parallel lode. The course is about North 60 degrees East, and there is a slight underlay to the North. The old workings were not accessible at the time of my visit except some close to the surface, which have recently been reopened, and from which some very fair copper ore had been extracted. The country is schist, lying in a belt parallel with the lode between large masses of crystalline diorite, the schist being very likely a portion of the diorite rendered schistose along a shear-zone. The lode has well-marked smooth walls, and consists mostly of quartz, often stained with oxides of iron and copper and carbonates of copper. In places the lode is as much as 20 feet wide, but the average is four to six feet, and the valuable ore-bearing material is usually confined, as far as can be seen at present, to portions only of the whole width. The owner of the "Fortune" ground, Mr. Watson, has collected a few tons of good copper ore, mostly carbonate and "liver" ore, and has shipped about four tons recently which gave a net return of £125. There are old shafts on this lease said to be down 60 feet and 40 feet, and a good deal of work must have been done in former days. There is a good deal of second-class ore about the surface that would probably be worth

putting through a local smelter, and probably a considerable amount could still be got from the old workings without opening much fresh ground.

In the "Aurora Australis West" there is an old shaft down some 60 feet, but all the recent workings are shallow. A few tons of picked ore have been stacked ready for shipment. In this lease there is what I take to be a strong heave of the reef to the North-West a distance of some 80 feet or so, or else there are two parallel reefs *en echelon*, one dying out and the other beginning opposite to its Western end but further to the North-West. On the West side of the heave there are several old shafts and workings which were probably made for gold, as the lodestuff in this part does not seem to carry very much copper, though often distinctly stained with it.

In the Government Geologist's Report of 29th August, 1906, on these mines it is stated that some of the ore outcropping in G.M.L. 61 assayed in the official laboratory 16.07 per cent. of copper. The easternmost of the two leases, G.M.L. 61, which was at one time known as the Glenderry, produced in 1901 22 tons of copper ore, valued at £287.

To get some idea of the suitability of the ore for smelting purposes I took a "grab" sample of the picked ore in some of Mr. Watson's ore heaps, which gave the following analysis :—

	per cent.
Moisture .. .. .	1.30
Silica .. .. .	29.09
Alumina .. .. .	.64
Magnesia .. .. .	.69
Lime .. .. .	trace
Iron .. .. .	25.12
Nickel .. .. .	.23
Copper .. .. .	18.15
Lead .. .. .	trace
Sulphur .. .. .	1.27
Oxygen, carbonic acid, etc...	23.51
	-----
	100.00
	-----

Equal on the dry ore to—

Copper .. .. .	18.39 per cent.
Silver .. .. .	5ozs. 0dwts. 8grs. per ton.
Gold .. .. .	2dwts. 13grs. per ton.

The analysis shows the sample to have been of excellent composition for easy smelting, being practically self-fluxing.



This is a strong lode and seems well worth opening up, but it is a great pity that information is not now available as to what was found out about it when the mine was originally opened.

About 12 chains (estimated) South of the above lode there are some fairly deep workings on a line of reef running about North 80 degrees East on what was formerly the Surprise lease, No. 132. and to the West of it. Two shafts are said to be down 70 feet, and the reef though rather small has been followed for about half a mile, though possibly not continuous. This reef also seems to be in a belt of schist traversing the diorite and probably in reality a zone of shearing in the latter. The reef is a large mass of quartz at the East end but only about 18 inches wide in the Western workings. No one was working on this reef at the time of our visit. A little copper is stated to have been sold from this reef and to have been found to carry gold. I took a grab sample of the quartz lying at the Western shaft to try for gold, but on assay it was found to contain neither gold nor silver.

*North and Brown's P.A.*—To the North of the Fortune Mine there are several copper-bearing lodes known to exist, several of which are shown on the Government Geologist's map accompanying his Report of 29th August, 1906. They strike more or less East and West, but very little can be seen of them at present. Messrs. North and Brown have reopened one of the old shafts, sunk some 40 years ago, and deepened it to 70 feet. The lode is only about 18 inches wide at surface, but at the bottom of the shaft it is 3½ feet wide. The strike is North 80 degrees West and there is a slight underlay to the South. The walls are smooth and well defined, the country being a thin belt of greenstone schist in crystalline diorite. Near surface the lode carries oxides and carbonates of copper, but these soon give place to chalcopyrite and marcasite. In the bottom of the shaft there is some sooty black sulphide of copper mixed with pyrites a sample of which, given to me by the owners, on assay yielded :—

				per cent.
Moisture	..	..	..	0.40
Silica	..	..	..	27.93
Alumina	..	..	..	7.47
Magnesia	..	..	..	3.00
Lime	..	..	..	trace
Iron	..	..	..	16.12
Nickel	..	..	..	.72
Copper	..	..	..	23.95
Sulphur	..	..	..	17.96
Oxygen, carbonic acid, etc...				2.45
				-----
				100.00
				-----

Equal on dry ore to—

Copper	.. .. .	24.05 per cent.
Silver	.. .. .	6ozs. 10dwts. 16grs. per ton.
Gold	.. .. .	5dwts. 11grs. per ton.

Another sample taken by myself from the cleaner chalcopyrite ore at surface was also analysed, yielding—

	per cent.
Moisture	0.19
Silica	18.98
Alumina	trace
Magnesia	.22
Lime	trace
Iron	30.94
Nickel	.79
Copper	15.25
Sulphur	28.02
Oxygen, carbonic acid, etc...	7.61
	-----
	100.00
	-----

The assay on dry ore being—

Copper	.. .. .	15.28 per cent.
Silver	.. .. .	2ozs. 5dwts. 18grs. per ton.
Gold	.. .. .	3dwts. 19grs. per ton.

The owners informed me that two tons of the ore sent to market realised 24 per cent. of copper, and that they had since shipped 11 tons more, but had not then received the assay returns. They had, however, been informed that owing to the presence of mareasite the parcel was somewhat poor. The second analysis quoted shows copper low in comparison with iron and sulphur.

At the bottom of the shaft this lode seems a nice strong little ore body, well worth opening up. There are, however, about 1,500 gallons per hour of water to be raised, which hampers the prospectors very much.

*White Australia, M.L. 114 (Application).*—About six chains North-North-West from North and Brown's shaft some work has

been begun by Machin and party on another East and West lode containing oxides and carbonates of copper, but the size of which could not be clearly seen.

Some seven or eight chains still further North-West there are some old workings in which is visible a strong lode formation about six feet wide between its walls, also running roughly East and West. In one cut on this there was a small vein on the South wall of rich copper sulphide (chalcocite or copper glance).

*The Roebourne Copper and Gold Mines, W.A., No-Liability ; Carlow Castle Mine M.L.65 (formerly M.L.14).*—There are six lodes distinguishable on this lease most of which were first opened up in former years and abandoned after a good deal of ore had been raised. They are now being again re-opened, but little new work had been done at the time of my visit. In the North-West angle of the lease there is a lode known as No. 1 or the "big" lode, on which there is an old shaft said to be 70 feet deep but now filled up to 50 feet. The lode is probably quite eight feet wide between its walls, but is not clearly seen and is composed of schist and quartz much stained with oxides of iron and carbonates of copper. At the 50 feet level a crosscut about six feet into the West wall of the shaft showed that this was still lode matter, and a seam was cut of very nice chalcocite ore, well worth following. With this exception, the lodestuff visible was poor in copper. To the South-East from these workings are others on No. 7 and No. 2 lodes, the latter being also called the "main" lode. It runs a little West of North and probably joins the No. 7 lode, which runs North-Easterly. There is a whip shaft 60 feet deep on the main lode, but at the time of my visit there was about 10 feet of water in it. Considerable stoping seems to have been done. The ore on the dump is quartz and oxide of iron containing frequent specks of native copper and a little oxide and carbonate of copper. Some of it also shows gold pretty freely. The lode is about four feet wide and in diorite country. The ore is silicious on the whole, but some of it contains so much oxide of iron as to be of good smelting quality, and seems likely to be worth sending to a local smelting works though too poor for shipment.

No. 3 lode is one found towards the North-East angle of the lease running North-Westerly, on which there is an old shaft about 75 feet deep and considerable old workings. The lode is about three feet wide and very fair oxide and carbonates of copper are said to have been got from it. I was told, but am without verification of the statement that one of the last parties who worked it made a profit of about £2,000 from their produce. From the appearance of the old workings it would seem likely that a fair shoot of ore existed



at this point and was worked down to the water level, but at present one cannot see if it continued in the bottom of the workings.

Lodes 4, 5, and 6 run North-Easterly, and but little work has been done on them. At No. 4 there is some fair ferruginous oxide and carbonate of copper ore, fit for shipment, and Nos. 4 and 5 lodes show copper-stained material.

At the time of my visit the present owners had shipped six tons of ore from the mine, but had not received the smelter's assay returns. The ore was expected however, to give less than 20 per cent. of copper.

The official returns recorded by the Mines Department from the Carlow Castle Lease are 159 tons of ore raised, valued at £2,459; there is, however, no certainty that these returns are by any means complete. The lease seems well worth further opening up. As will be seen from the following extract from the Government Geologist's Report of the 29th August, 1906, the copper ore is stated to contain quite appreciable values in gold

"Samples of the ore from the North-West vein, which outcrops on the North-East corner of the property assayed in the official laboratory (6424, 6425) 12.77 and 34.22 per cent. of copper.

"In 1898 the files of the *Northern Public Opinion* mention two shipments of copper ore from the 5-Mile Copper mine, viz. : (a) 9 tons giving a return of 31 per cent. of copper and 3dwts. of gold, and (b) 1½ tons yielding 16 per cent. of copper and 1½ ounces of gold per ton.

"The same paper states, in February, 1899, that the mine was sold for £32,000, but in the month of July work ceased owing to the influx of water. A small syndicate of Roebourne residents appear to have worked the mine in 1900, and about 20 tons of ore were bagged and shipped. The ore is stated to have assayed as high as 30 per cent. of copper. In the month of February of the following year, 30 tons of ore were sent to Adelaide and Fremantle for treatment, and are reported to have yielded 24 per cent. of copper in addition to 14dwts. of gold.

*Lily Blanche Mine, M.L. 77.*—This mine is situated about two miles west from Roebourne, on some small diorite hills. A lode has been found on it running nearly north and south, which has been opened by two shafts to a depth of 40 feet. At surface the lode was very small, the outcrop being almost imperceptible, except for occasional copper stainings on the rock. On sinking, however, upon it, it soon opened out, giving at first some very fair oxidised copper

ore, which soon changed to chalcopyrite. A shoot of ore about 76 feet long has been stoped, the lode averaging about five feet in width of ore mostly worth saving. In one place, however, I noticed a "splice" of poorer iron pyrites on one of the walls. The walls are smooth and distinct, the lode being a fissure vein cutting through the enclosing diorite country. In the bottom of the north shaft it was three to four feet wide when I saw it, there being nearly three feet in width of clean chalcopyrite ore. Elsewhere there is some quartz gangue and "horses" of country, and the lode is in places as much as eight feet wide. The workings are not yet extensive, but the ore has been so good that the mine has been a very profitable one to its owners, and when I saw it there seemed every prospect of its maintaining a fair output of ore. The owners informed me that they had raised since February last about 400 tons of ore containing about 24 per cent. of copper, and 20 tons estimated at 12 per cent. They had lately shipped 81 tons averaging 26.8 per cent. of copper, and had another good parcel on the wharf waiting shipment. Twenty-one men were being employed underground and about 10 on surface, and £1,580 had been paid for wages alone.

The official returns from this mine to 30th April, 1907, show 303 tons of ore shipped valued at £6,060, containing 60.60 tons of metallic copper, or an average of 20 per cent.

The present workings are just upon the water level, and machinery will soon have to be provided for raising the water in order to allow deeper sinking. This mine is at present the mainstay of the Roebourne Copper Mining industry, and much depends upon its success.

*Ena M.L. 68.*—According to the lessee there are seven lodes on this lease, on which a little prospecting has been done. One of these runs north 50 degrees east, and has little underlay. Its immediate walls are greenstone schist, but this changes quickly into the ordinary massive diorite of the country at a little distance from the lode, the schist being apparently simply the diorite rendered schistose along a line of shearing. The shallow trenches on the outcrop show about two feet in width of rubbly iron and copper-stained quartz. Ten tons of picked ore from this and other lodes on this lease are said to have returned 15 per cent. of copper on bulk assay. To the north-east of these workings there are two lodes close together, running about north 20 degrees east, which show some fair-grade ferruginous oxide and carbonate copper ore. East from these workings is a fairly long line of lode running north 10 degrees east, which has been traced over a somewhat steep hill. At the north end of this outcrop a shaft has been sunk 30 feet deep, in poor ore. I was informed, however, that there were about three feet of ore in the bottom of the shaft, but could not get down to see this. Cuttings

into the outcrop south of the shaft showed copper-stained rubbly lode matter, from which a small amount of fairly good oxide ore could be got. This lode could very readily be prospected by driving a tunnel along its course from the gully at its south end.

The Ena lodes are, as yet, very little opened up, and do not show much ore; but they seem well worth further prospecting.

*Proposed Smelting.*—It will be seen that with the exception of the Lily Blanch none of the Roebourne Copper mines are at present regular producers of copper ores to a serious amount, though some are very promising prospects. As they are more opened up, however, the question of the treatment of the ore will become of increasing importance, and already the mine owners are making inquiries as to cost of smelting plant of reverberatory and blast furnace type. In this, as in most other districts, it is all very well to begin with shipment of the richest ores, but there soon come to be accumulations of poorer stuff that will not pay for shipment, but which could be treated locally either by concentration for shipment in the case of some sulphide ores, or by local smelting. The sulphide ores of the Roebourne District would be of great value in smelting the poorer classes of oxidised ores at Whim Well, and it seems possible to make arrangements whereby the cost of transport from the mines to Point Sampson jetty and thence to Balla Balla would not be excessive, but unless this could be done very cheaply it would probably soon be preferable to smelt near Roebourne. If active prospecting work continues to be carried on in the district, it should be possible very soon to come to a conclusion as to when the establishment of a local furnace would be justified. As soon as there is reasonable certainty that supplies of ore will be forthcoming sufficient to keep a furnace in fairly constant operation, every encouragement should be given to any person or company proposing to establish such.

The officially recorded returns of copper ore from the Roebourne District are shown in the following General Table of copper production of the West Pilbara Goldfield.

#### GOLD MINES.

The copper ore of this district seems usually to carry a little gold, though often rather poor in the precious metal, and it has been above noted that the gold values in the Carlow Castle stuff are often considerable. There are, however, also mines in the district whose value is in gold alone, the reefs being fairly clean milling ore, with only occasional stains of copper carbonates. It remains to be seen if there is so much copper as to interfere seriously with cyanide treatment; at present the mines are not opened up enough to give a definite opinion on this point. The gold mines seem to be in the schist country, which is probably diorite schist, but may possibly be found to belong to the Mosquito Creek formation of the geological survey.



*Copper Production of the West Pilbara Goldfield as*

Locality.	No. of Lease.	Registered Name of Company or Mine.	Previous to 1899.		1899.	
			Tons of Ore.	Value. £	Tons of Ore.	Value. £
Roebourne .. ..	14	Carlow Castle Copper Mine ..	85	1,190	48	801
	42	Federation (now part of same ground as Carlow Castle)	..	..	..	..
	49	Glenderry .. .. .	..	..	..	..
	77	Lily Blanche .. .. .	..	..	..	..
Whim Creek .. ..	34 (5.12)	Balla Balla Copper Mine ..	..	..	725	4,945
	Freehold	F. W. Prell & Co. (now Whim Well Copper Mines, Ltd.)	6,638	49,785	1,405	20,196
	100 acres					
	Loc. 71					
	10	Rushall's Lease .. .. .	20	150	..	..
	33	Stranger's Copper Mine ..	..	..	10	100
Croydon .. ..	26	(Croydon Copper Mine) ..	15	245	25	350
	31	Evelyn Copper Mine (now British Exploration of Australasia, Ltd.)	..	..	134	1,363
Egina .. ..	3	Egina Copper Mine .. ..	260	3,900	208	1,723
Total .. ..	..	.. .. .	7,018	55,270	2,555	29,478

*reported to the Mines Department to 30th April, 1907.*

1900.		1901.		1902 to 1906.		To 30th April, 1907.		Total.		Total of each District.	
Tons of Ore.	Value. £	Tons of Ore.	Value. £	Tons of Ore.	Value. £	Tons of Ore.	Value. £	Tons of Ore.	Value. £	Tons of Ore.	Value. £
26	468	..	..	..	..	..	..	} 159	2,459	484	8,806
..	..	22	287	..	..	..	..		22		
..	..	..	..	..	..	303	6,060	303	6,060		
1,198	6,493	86	598	..	..	..	..	2,009	12,036		
..	..	1,054	15,006	..	..	804	21,398	9,901	106,385		
..	..	..	..	..	..	..	..	20	150	11,940	118,671
..	..	..	..	..	..	..	..	10	100		
319	4,230	..	..	..	..	..	..	40	595		
..	..	..	..	..	..	..	..	453	5,593	493	6,188
62	948	..	..	..	..	..	..	530	6,571	530	6,571
1,605	12,139	1,162	15,891	..	..	1,107	27,458	..	..	13,447	140,236

*Weerianna Mines.*—These lie  $1\frac{1}{2}$  to 2 miles west of Roebourne, on the western side of the hills immediately west of the town. The hills at the foot of which the mining belt lies are a large outcrop of the ferruginous quartzite and dark jasper formation striking north-easterly, parallel with the principal course of the reefs. The quartz reefs, which are numerous, are found in a belt of country lying along the foot of the quartzite hills and nearly a quarter of a mile wide. About half a mile north-east from the old Herman's Reward workings there is a very large prominent outcrop of white quartz forming a conspicuous feature in the landscape, which seems to be probably part of the same reef, or group of reefs, as again outcrops boldly about a quarter of a mile west of the same old mine. These reefs do not seem to have been worked upon, so presumably no gold has been found yet in the quartz. They seem to form the western edge of the belt of reef-bearing country lying between them and the quartzite hills. In this belt outcrops of quartz are very common, and it is at present impossible to say how many reefs there are, the belt being more or less seamed with them. Their course seems to be generally about north-east and south-west.

*Herman's Reward.*—On this old lease, not occupied at the time of my visit, there are two old shafts which seem to be somewhere about 40 feet deep, and some open-cut workings, but it is not quite clear how many reefs were worked. The principal one seems to be that worked in a cutting on the outcrop, where a body of quartz is seen about 2 feet 6 inches to 3 feet wide, striking north-easterly and dipping somewhat flatly to the south-east. The quartz is stained with oxide of iron, and also at times with a little oxide and carbonate of copper. Having been informed that recently taken samples from the outcrop had yielded assay returns of about 25 dwts. gold per ton average I took a sample bagful of chips from the outcrop and the broken quartz lying beside it, which was assayed in Perth and gave:—Gold, 4 dwts. 9 grs. per ton; and silver, 6 dwts. 13 grs. per ton, showing that the place is worth further prospecting and testing. According to the Government Geologist's report of 29th August, 1906, it is recorded that in 1897 there were crushed from Herman's Reward 8.45 tons of ore for a return of 100.50 ozs. Three tons treated at Dry Creek, South Australia, are also stated to have returned 45.00 ounces of gold. The files of the *Northern Public Opinion* show 12 tons treated in 1897 for 142.60 ounces, these figures, though not exactly agreeing with the above, referring probably to the same returns. The information given to the Government Geologist over a year ago by Mr. Chas. Bull, who was then prospecting the locality, to the effect that "he had found several small patches of rich stone, but there appeared to be no permanence in the shoots," seems therefore to have been very probably a correct summing up of the state of affairs. The amount of work done, however, is not enough to demonstrate that the reefs are unpayable



altogether, and they seemed to me well worth testing in a more systematic manner to ascertain if they could not be worked as a proposition of somewhat low average grade, with chances of occasional rich bunches of ore.

*Welcome G.M.L. 75.*—In this old lease there are several shafts sunk on a large body of quartz, said to be of low grade. The reef is in soft schist country close to the foot of the quartzite hills. No work has been done on this of late years, and no crushing returns are recorded.

*Porterminna G.M.L. 135, and Porterminna Extended G.M.L. 136*—These leases have been taken up on parts of the old holdings of the "Eureka" G.M.L. 94, and "Golden Pile" G.M.L. 90, the workings being on the old shafts of these two former leases and on a new discovery about half-way between these. At the time of my visit the "Golden Pile" shaft had water in it, and nothing could be seen, though some work had been done recently. It was 90 feet deep with water up to 76 feet, the quantity of water having lately become too great for sinking to be continued by manual labour alone. The reef is about 2 feet thick, of white quartz, striking north 64 degrees east, and dipping vertically. The manager told me that assays of from 15 to 20 dwts. gold per ton could be got at 25 feet in the shaft across a width of two to eight feet. According to Mr. Beecher, Inspector of Mines, quoted in the Government Geologist's report of 29th August, 1906, the prospectors in 1896 had got coarse gold in the stone, and some beautiful specimens had been obtained. There is, however, no official record of their returns from ore crushed.

The "New Find" had been struck only a day or two before my visit, and all the work done on it was a hole about six feet deep, in which the size of the reef could not be distinctly seen. The stone is bluish quartz with stains of green carbonate of copper, and a few specks of galena, and some of it was very rich, though the gold was fine. I was told that some of this stuff assayed 41 ozs. to the ton, which was quite credible for such picked stone. I took a bag of fragments from the heap thrown out of the hole on the lode, which gave on assay:—Gold, 2 ozs. 17 dwt. 17 grs.; and silver, 18 dwts. 12 grs. per ton. The reef seems to be a fairly strong body of quartz, and is a very promising prospect.

The "Eureka" shaft is sunk vertically 45 feet and then goes 30 feet deeper on the underlay of the reef to the south-east. The reef runs north 67 degrees east, and underlays south-east about one in 10. There is a hard bar of bluish quartz, and on the sides of it the soft schist country carries numerous veins of quartz and is auriferous for some width. I was informed that a recent sampling

had given an assay value of over an ounce of gold per ton over a width of 10 feet. At the 45 feet level some crosscutting has been done, showing a width of over 20 feet of schistose lode matter, which I was informed was poor on the whole, but contained some rich veins. The lode seems to be a rather wide "formation" of schist and quartz leaders, and will require considerable opening up before much can be said about its value. The owners seemed very well satisfied with their prospects. Another little reef of bluish quartz is seen about 150 feet north of the "Eureka" shaft, in which assays are said to have been got of about seven dwts. gold per ton, and it seems probable that there are several parallel reefs in this part of the mineral belt.

I took a sample of the schist and quartz lying about the dump at the "Eureka" shaft, from several places and the assay return was:—Gold, 1 oz. 7 dwt. 5 grs. per ton; silver, 18 dwt. 12 grs. per ton, which shows that there is some very payable ore to be had. This property seems very well worth thorough prospecting, and seeing that there is a stretch of proved auriferous ground nearly a mile in length from the "Herman's Reward" to the "Eureka," and that the reefs are numerous, it seems to me that there is a very fair chance of an important discovery being made in this Weerianna belt.

The Government Geologist's report of 29th August, 1906, gives the yield of gold from the "Eureka":—

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1897 ... ..	10·90	125·00	11·45
1900 ... ..	5·90	41·80	7·08
1905 ... ..	4·00	31·05	7·76
Total ...	20·80	197·85	9·51

There are no crushing plants at present available in the vicinity of Roebourne at which trial crushings could be made, the nearest being a small prospecting battery at Nichol Bay, some twelve miles distant from Weerianna. It will therefore be necessary for a battery to be obtained soon in order that the reefs may be satisfactorily tested.

#### LOWER NICHOL DISTRICT.

About 14 miles west of Roebourne at the head of the estuary of the Nichol River there are several gold-bearing reefs on which some work has been done, and there are considerable alluvial workings. The latter have been worked off

and on for a long time past, and two dryblowers still on them are stated to have made a living there almost continuously for several years. I was informed that several "slugs" of from five to ten ounces in weight had been got at various times. The ground is mostly shallow, but some of it in the flats along the estuary is stated to be about nine feet deep. There is said to be gold in the mud-flats of the estuary and some little time ago there was a proposition to work these deposits by dredging, but nothing has yet come of this. I cannot express any opinion upon the feasibility of this proposal on the little I could see of it in a flying visit. Systematic testing of the ground to be dredged is obviously necessary before a reliable opinion could be formed.

Near the head of the estuary there are several outcrops of reefs seen projecting from the mud-flats, and some are also seen a little farther inland, as far as the old King's mine. These reefs run fairly parallel to one another on a course of about north 70 degrees east with a slight tendency to converge towards the east end. They are in schist country, well laminated, which I think will prove to be diorite schist.

*The King's Gold Mines—Old G.M.L. 122.*—This reef runs north 70 degrees east, and dips south-east 40 degrees to 60 degrees. It has been traced by workings for some considerable distance, but these are not now accessible underground. The water level is about 20 feet below the surface. None of the workings seem to have been extensive. The reef shows 18 inches to two feet of quartz, lying parallel with the laminations of the schist. I take it to be a fissure lode and a fairly strong one. The quartz carries some copper minerals, and a little gold can be seen at times when examining the stone. One prospector does a little work on this reef from time to time, getting out stone from near the surface. The mine has not been worked seriously for several years. Its recorded output is shown below in the general table of returns from the West Pilbara Goldfield.

*Ninety-Nine G.M.L. 106, and Century G.M.L. 109.*—The Century reef is the furthest north of the group of parallel quartz reefs opened in this locality, and outcrops in the beach under the high-water mark of the estuary. Where the outcrop has not been cut away it stands out from the beach as a little wall of quartz up to two feet in height, but most of it has been taken out to depths of from five to 25 feet, the excavation forming a straight trench across the beach, at present full of water. The reef is remarkably regular in size, strike, and dip, realising the ideal appearance of a reef as shown in text-book diagrams. Its average width is about two feet. The quartz is stained a good deal with oxide of iron and at times with copper carbonates. Some very rich stone obtained from it



was shown me by Mr. Tozer, who has been working it. This came mostly from a shoot of ore towards the east end of the outcrop, where it leaves the beach and crosses a flat ridge running out into the mud-flats. A little further east the reef bends slightly and seems to divide into two or more branches. It is said, however, to be visible again across Nichol Creek, on the east side of the estuary. North of this reef there is an outcrop of hardened and silicified schist which forms a bar across the beach, and Mr. Tozer informed me that he had never known the tidal waters to come past this bar. The workings were full of water at the time of my visit, but he said that water was not troublesome when the mine was in operation, the country schist being apparently fairly impervious to water. There does not seem, therefore, to be much reason to fear that the reef will not be workable on account of its being on the sea beach, although it will clearly be necessary to take precautions to prevent an influx of water in the event of an abnormally high tide. The beach is so flat that a protective bank of earth need only be a very low one. Mr. Tozer has a 3-head prospecting battery of 250 lb. stamps near his mine, and informed me that he had crushed 100 tons of ore with it from this mine with an average return of about 3oz. per ton, tailings assaying 12 to 15dwts. per ton. About four years ago Mr. J. W. Archibald worked this reef, and also took the outcrop stone from several parallel reefs lying between it and the Kings reef, crushing the stone with a 10-head battery, since removed, the boiler of which is still on the ground. He has informed me that he crushed about 800 tons from the reef for an average return of 4dwts. of fine gold to the ton, and that there were  $2\frac{1}{2}$ dwts. per ton fine gold in the tailings. He also crushed about 50 tons of schist from near the reef.

The group of reefs at the Lower Nichol seemed to me well worth further attention from prospectors, the trial that has been already given to it being by no means conclusive. The reefs are distinct and strong, and the Century and Kings reefs have been proved to carry gold for fairly long distances along their outcrops. The country rock is easily workable, and access either by land from Roebourne or by sea from Nichol Bay is not difficult. Supplies of mining timber and firewood are not good, but are better than in most of the Pilbara fields, there being a good deal of timber in the valley of the Nichol river within reasonable distance for carting.

The recorded returns from the Lower Nichol district are shown in the following General Table of Gold Production of the West Pilbara Goldfield.

*Gold Production of the West Pilbara Goldfield as reported to the Mines Department to 30th April, 1907.*

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*Iron Deposits.*—About 6 miles from Roebourne, on the road to the Lower Nichol, the road passes a great outcrop of dark oxide of iron, which seems to run north-north-easterly. I did not examine this when driving out to the Nichol, but from the cursory glance obtained in passing there seems to be a very large deposit in the form of a lode, which might be very useful as flux for the copper melters.

*Other Discoveries.*—While at Roebourne I heard of several prospectors having found gold at various points in the surrounding district, and there seems little doubt that several mines will be opened up if the prospectors are well supported by the investing public. The country is favourable for minerals, and much more easily accessible and cheaply workable than the inland fields.

*Clarke's Antimony and Gold Mines.*—Owing to receiving information that work had been abandoned, and the application for leases withdrawn, I did not attempt to visit this mine which has since caused me much regret, as it turned out that the information was to some extent due to a misunderstanding. Mr. Clarke saw me in Roebourne, when there was no longer time to go out to the mine before the arrival of the steamer by which I had to return to Perth, and told me that he had been working the mine till a few days before and intended to continue work as soon as a difficulty could be settled between himself and the directors in Adelaide of the Clarke's Antimony-Gold Syndicate, N.L. He exhibited some very fine specimens of quartz, carrying sulphide of antimony through it, and very rich gold, and of very pure solid stibnite (sulphide of antimony) and cervantite (oxide of antimony), and informed me that the lode has been traced through two blocks of 40 acres each taken up upon and was as much as 12 feet wide at surface. Very solid and pure stibnite is said by him to be readily obtainable in good quantity, and the rich gold ore occurs in a short shoot in a good-sized reef which is of fair value outside the shoot. Two shafts have been sunk, one 25 feet deep, the other 40 feet. The mine is near the crossing of the Sherlock River, on the road from Roebourne to Croydon, about 39 miles from Roebourne and 16 miles from Croydon station. It is about 24 miles from Balla Balla, and eight miles from Sherlock Station. I cannot vouch for the information obtained from Mr. Clarke, but he has without doubt some excellent stibnite and some rich gold-bearing ore, specimens of both from his mine having been shown to me at Station Peak and Croydon by others, as well as by himself at Roebourne. The discovery seems to me well thought of by local residents who are in a position to know the truth about it.

*Fuchsinite Rock.*—A piece of very green coloured rock was given to me at Roebourne by Mr. A. G. Holroyd, found in the vicinity of the Sherlock Station, which is worth noting on account of its

very close resemblance to rock coloured with green carbonate copper, being thereby very liable to mislead prospectors. It contains neither copper nor nickel, the two metals usually responsible for bright green colouring of ores. The Government Mineralogist and Assayer examined it, and reports it to be a "Fuchsite-rock, composed almost wholly of minute scales of chrome-mica (fuchsite) which is of a bright green colour. It is of no value, the quantity of chromium in it being too small to allow of its use for production of chrome compounds.

#### WHIM CREEK DISTRICT.

The principal mine in the Whim Creek district is that of the Whim Well Copper Mines, Ltd., on Northern Location 71, which lies about 13 miles south of the jetty Balla Balla, and eastward from Roebourne some 50 miles by road. There are also workings at Mt. Negri, about four miles north from the Whim Well mine, and rather less than three miles south-south-westerly from the latter lie those of the Mons Cupri mines. At the time of my visit work was confined to the Whim Well Company mine and two adjacent leases.

The Geological Survey of the West Pilbara Goldfield has not yet been completed in the Whim Creek district, and my fly-geological examination of the country in this neighbourhood was much too brief to enable me to say with any certainty to which of the formations previously mentioned in the Geological sketch the principal rocks of the locality should be referred. Those of the Whim Well mine and its immediate vicinity are mostly laminated slates and schists, varying very much in strike and dip, but generally dipping northerly at somewhat flat angles. The strike varies in short distances from north and south to east and west, and the dip from easterly to northerly. On the whole the slate appears to be a somewhat flat-lying series of strata very much crumpled. At the Mons Cupri the mine workings are mostly in indistinctly bedded rocks composed of fragmentary argillaceous and arenaceous material with frequent enclosures of rounded subangular pieces of older rocks. The strata are of somewhat tufaceous nature, but I was unable to satisfy myself whether they were purely sedimentary debris of felspathic rocks, or truly volcanic tuffs and agglomerates. The strike is not clearly seen, but appears to be more or less north-west and south-east, with slight dip to the south-west. Near the mouth of the lowest tunnel, or the southern side of the hill, there is a massive igneous felspathic rock which may be a dyke, and a somewhat similar one is seen at the water shaft. The rocks at Mons Cupri are much weathered, and it is therefore somewhat difficult to determine their true classification without more extended examination than I had time to give them. From the fact of the strata throughout the district having generally low angles of dip and apparently forming portions of a much crumpled but on the whole rather flat-lying

es, they seem more likely to belong to the "Nullagine Beds" of the Geological Survey than to any other formation yet recognised in the Pilbara Fields. In support of this it may be mentioned that the road from Mallina to Whim Creek passes over hills on which vesicular lavas are largely developed, quite similar to those characteristic of the Nullagine formation in its typical occurrences at Marble Bar and Nullagine. Igneous rocks very like these are also seen on the road between Whim Creek and Mons Cupri. I did not notice any showing the characteristic vesicular structure.

Unusual economic interest attaches to the geological structure of this district on account of the principal ore-body yet discovered, the Whim Well lode, being possibly a truly bedded deposit. It is very nearly if not quite in the bedding of the enclosing slates, and appears to have been in existence when they were subjected to rumpling through movements of the earth's crust, as it partakes as far as yet seen—of the same bends and twists as the enclosing slates. It may prove on further opening up to be a fissure lode, possibly following the bedding of the slate where seen at present, possibly crossing it in depth, or it may be that it is similar in formation to the celebrated copper-bearing schists of Mansfield, Saxony, where there is a truly bedded stratum of cupriferous schist extending over an enormous area. At one time it was generally considered that the copper ores of the Mansfield schist were laid down simultaneously with the sediments enclosing them, but more modern authorities mostly regard them as subsequently introduced, holding that they have been precipitated in the layer of "copper-schist" from solutions traversing the country on account of the schist having been in some way either more permeable than the strata above and below it, or containing constituents which allowed special precipitation of the ores. The occurrence of the copper ores in the "copper-schist" is thus similar to that of gold in the "banket" reefs of South Africa, and the conglomerate at Nullagine, in both of which cases gold has been deposited by secondary processes in the interstices between the pebbles of a conglomerate. The ore deposits, however, in all these cases are closely associated with the favourable stratum, and for mining purposes this may be regarded as a bedded deposit. As seen at present there seems to me to be a very considerable possibility that the Whim Well "lode" is such a deposit, and if so it may be of much industrial importance to determine the position of the cupriferous layer here in the district by careful correlation and mapping of the enclosing strata. Should further exploration, however, prove it to be a fissure lode, and that its apparently bedded nature is merely a fortuitous coincidence, no special importance would attach to its position in the series of sedimentary strata.

Mr. E. J. Dunn, F.G.S., when reporting on the Whim Well lode on 8th January, 1898, noted the conformity of the lode with



the bedded planes of the country slate, but was of opinion "the lode consists of a very compact felsite rock of igneous origin containing veins, branches, and masses of copper oxide, carbonates, etc. Mr. C. E. Gibson, Assistant Government Geologist, in report of 12th March, 1906, also considers that the mass of the lode is of igneous origin, regarding it as a dyke of "what appears to be a decomposed serpentine (?)" which "has undergone considerable alteration down to water-level, and appears as a soft light-colored aluminous rock, which near the surface is highly impregnated principally on the hanging wall side—with copper, which occurs as veins and masses of blue and green carbonates." My own observations did not induce me to adopt the view that the lode was originally an igneous rock, whether regarded as an intrusive dyke or sill, or an interbedded lava sheet, though in places there are occurrences of indurated aluminous material that strongly suggest an altered felsite, as I saw nothing in the lode stuff which seemed to me indubitably of igneous origin, and which could not equally well be accounted for by alteration of a bed of the "country slate" by the action of lode-forming agencies and subsequent supergene weathering. In the largest and richest parts of the lode yet worked the copper ores have been usually found in a gangue largely composed of kaolin, and while this could be formed by decomposition of a felsite it could equally well result from hydrothermal or permatolytic action upon aluminous slates, or even from the chemical reactions which commonly take place in the portions of lodes at the water-level owing to oxidation of sulphides and access of downward percolating surface water. The whole of the mine workings are as yet in the zone of oxidation above the permanent water level, and in consequence we find the usual features of copper ores under such conditions, viz., gossans nearly free from copper on the surface, and beneath them weathered lode matter much stained with carbonates and oxides of copper and iron oxide, and containing rich secondary aggregates of oxidised copper ores in veins, bands, and impregnations, followed, a little lower down, by rich secondary sulphides. In all this part of the lode there has been considerable chemical action owing to the oxidation of the original pyritic constituents, soluble constituents being largely removed both from the lode-slate and the wall rock, leaving a residue of kaolin. The position of silica as quartz and chert is also a common result of weathering reactions. I saw nothing in the Whim Well lode which did not seem easily explainable on this basis without supposing there had been any igneous dyke, and in the deepest workings the gangue seemed to me to be very similar to the enclosing country slates without any appearance of turning into felsite or other igneous rock.

*Whim Well Copper Mines, Ltd.*—This Company was formed in July, 1906, with a capital of £25,000 in 25,000 ordinary

of £1 each, which was, in December of the same year, increased to £150,000. The Company owns location 71 of 100 acres as a freehold, and has also applied for several mineral leaseholds under the Mining Act, 1904. The freehold is on a range of small hills, the ridge of which runs roughly east and west a short distance to the north of the south boundary of the holding. The outcrop of the lode is traceable through nearly the whole length of the freehold (50 chains), and is seen again in the ground held by the Whim Well East Copper Co., which adjoins its north-east angle. The dip is somewhat flat, and often nearly the same as the slope of the hills to the northward, consequently in many places there is very little country rock covering the lode, and it is seen lying bare on the surface of the hill. In some of the gullies it has been partially removed by denudation, and on the ridges it is under considerable cover. Owing to the flat dip of the lode and the slopes of the hill therefore, the outcrop is very sinuous. As already mentioned, the lode itself is crumpled conformably with the enclosing slates, and therefore varies a good deal in both strike and dip. The top of the hill where the lode crops out has been cut about in every direction by open cuts, trenches, and shallow shafts, while lower down several small tunnels have been put in, from which ore has been stoped out. There are also several old tunnels, put in before the present Company acquired the property, which go away into the footwall country of the lode, and which were from the first plainly useless for working it, but may have been thought judicious for prospecting purposes. In one of these, under the western surface workings, there are strings of ore through weathered country rock, and a winze has been sunk some distance on a vein of ore dipping oppositely to the main lode. The ore at this point, however, seemed to me to be more likely due to downward percolation of copper-bearing solutions from the lode above during its decomposition through weathering than to original veins, though the vein in the winze may perhaps be of more permanent character.

At several points on the outcrop there are occurrences of brown and black oxides of iron and manganese, often somewhat siliceous, of cinder-like texture, which probably represent the oxidised remains of original bodies of pyrites in the lode. One of the largest of these is nearly over the "ball-room," a large underground excavation from which most of the 1,054 tons of first-class ore shipped in 1901 were obtained. The ore in this excavation was mostly "liver" or "tile" ore, a mixture of oxides of copper and iron, with a considerable amount of green carbonate of copper. Some copper glance and black oxide of copper were also obtained. The ore was of secondary nature, evidently a chemical concentration, and was doubtless formed by precipitation from cupriferous solutions from higher parts of the lode. In the main workings of the present Company there is a large mass of rich ore of similar forma-

tion, rich oxides, carbonates, and glance (sulphide) ore being distributed through a kaolin and brown iron ore gangue.

As the slope of the hills flattens out towards the plain the lode dips deeper under the surface, and two shafts have been sunk to a depth of about 80 feet to cut it. In the more easterly one the water-level is at about 78 feet, and a crosseut has been put in at 70 feet some 15 feet or so to the hanging wall of the lode. The crosseut then goes on for 24 feet before cutting the footwall, showing the lode to be about six feet thick measured at right angles to the walls. This lode-stuff contains some very good glance ore, and is said to have averaged six to 10 per cent of copper when being excavated. A drive has also been made westward along the lode to connect with the other shaft. The bedding of the country at this place runs about north-west and south-east, and the dip is to the north-east, the lode conforming with the stratification. The lode-stuff is still much weathered, and the copper ores are still concentrated secondary products. Probably pyritic ores will be met with before going much deeper. The lode is "living" very satisfactorily at the depth at which it is seen in the shafts, and the material composing it seemed to me to be more of the nature of the filling of a fissure lode than of a bedded deposit. There is a very large area of ore-bearing stuff now proved between the 70-feet level and the top of the hills, and extension of the level along the course of the lode will rapidly increase the reserves of ore which may be regarded as "in sight."

The deeper development of the mine below water-level will require shafts still further to the north than the above, but before settling on sinking these I would strongly advocate testing the deposit in depth by diamond drill boring. The flat dip makes this method of trial particularly serviceable, and numerous holes could rapidly be run down to cut the lode so as to prove its position and give some information as to its value, and would serve to enable a main shaft to be located to the best advantage. It is important to open the lode below the water-level, not only for the purpose of exploring the mine and increasing the ore reserves, but also to provide sulphide ores with which to smelt the lower-grade oxidised material from the shallow workings, of which there is a very large quantity available.

The thickness of the lode is very variable in the various workings, being over 30 feet in some of the big kaolin bodies, and going down in other places to about two feet, or even less. In the oxidised zone there has been so much precipitation of ore in the wall rock that it is often hard to say how much of the stained cupriferous matter should be regarded commercially as part of the lode, and the width worked will depend on the extent to which the values are payable. Taking the exposures all through, the lode would probably average fully six feet in thickness.



The yield of ore from this mine has been very good, the official returns being :—

Year.	Tons of Ore.	Value.
		£
Previous to 1899 ...	6,638	49,785
1899 ...	1,405	20,196
1900 ...	<i>Nil</i>	<i>Nil</i>
1901 ...	1,054	15,006
1902 to 1906	<i>Nil</i>	<i>Nil</i>
To end of May, 1907 ...	976	25,340
Total ...	10,073	110,327

The present company have up to the end of May shipped about 1,100 tons of ore averaging 26 per cent. of copper (not yet all included in the above return) and almost the same amount shipped in 1901 had the same average copper contents. The ore previously shipped is said to have yielded from 22 to 40 per cent. of copper. When Mr. E. J. Dunn reported on the mine in January, 1898, he sampled 17 dumps and ore-heaps, mostly second-class stuff, containing 3,600 tons of ore and obtained an average assay value of 11.16 per cent. copper, but he points out that 800 tons of 22 per cent. ore had been picked out of this and shipped as well, giving an average for 4,400 tons of 15 per cent. copper. My visit was much too short to permit of sampling or of making any measurements of the dumps now on the mine, but the manager's rough estimate of 10,000 to 12,000 tons of second-class ore on the various dumps, of assay from 8 per cent. to 10 per cent. copper, seemed very reasonable. The amount of ore in unbroken faces was very much larger, and according to the manager's sampling and assays many of these gave bulk values of from 10 to 15 per cent. of copper. In 1898 Mr. E. J. Dunn estimated the ore available from short adits and open-cut workings at 130,000 tons, and a more recent report, dated November, 1906, by Mr. R. Schloesser, estimates 200,000 tons as available above water-level. In the present state of the mine such calculations can only be taken as attempts to approximate in figures to the quantity which on present knowledge seems likely to be obtained, and taken with this reservation they do not appear to me to be in any way unreasonable. The quantity of ore that there is every reason to expect can be got is plainly very large.

At present the first-class ore is picked by hand and bagged for shipment to Europe and to facilitate this process the Company are about to erect ore-bins and machinery for better handling and dressing. This plant will greatly reduce the cost of hand-dressing the ore, but is not a concentrating plant in the ordinary sense of one in which the ore is separated from the gangue by means of

water or a pneumatic treatment. The rejected material will still contain a very appreciable amount of copper.

According to figures given to me by the manager, Mr. Sleeman, the total costs of mining, shipping, and realising ore containing 25 per cent. copper, including smelters' deductions from the assay value, under present conditions have worked out at about £10 12s. 2d. a ton equal to 10.61 units of copper when the metal is worth £100 per ton (or 20s. per unit). Of these charges bags, bagging, and loading amount to 17s. a ton, cartage to the coast, lighterage, wharfage, and agency, 30s. a ton, and ocean freight and insurance 37s. a ton, the total of these items being £4 4s. per ton. By having a tramway to the coast and making arrangements to ship the ore in bulk by sailing vessel there is much hope that it would be possible to cut down expenses between the mine and the European smelter to from 27s. to 30s., or say £2 15s. less than at present. The dressing plant will probably reduce present costs of dressing quite 4s. a ton, but it is unlikely that mining, administration, smelting and realisation charges would be greatly different from those now prevailing. Probably the costs might be reduced by an amount of about £3 a ton in all, to say £7 12s., equal, with copper at the same price as above, to 7.60 units. This, however, would represent the lowest grade of ore that would cover expenses, even at the present good price of copper, and would necessitate very excellent arrangements for shipping the ore. Should copper fall to 15s. per unit (£75 per ton), it would require nearly 10 per cent. of copper in the ore to pay the expenses. But ore of from 7½ to 10 per cent. copper should be capable of being smelted locally at a good profit, so it seems to be indicated that local smelting is desirable. As above noted there is a large amount of ore of about this grade already broken out on the dumps and much more in sight, and though doubtless this could be picked over and dressed so as to yield a shipping grade of say 12 to 15 per cent. and seconds of less than 5 per cent., it seems to me, without having gone fully into the matter, that local smelting *en masse* would be likely to be the more profitable policy. The question, however, is one for very close calculation of relative costs and profits by those immediately interested, and it may be that they might find it would suit them best to pick and ship for a time. Whether local smelting or foreign shipment is chosen, there will be in either case a large amount of low-grade oxide and carbonate ore rejected from the superficial workings of the mine, and the question of treatment of this by a lixiviation process will deserve very serious attention.

The Company have already decided to construct a tramway, or light railway, from the mine to Balla Balla, and this work is to be gone on with very shortly. The distance is stated to be 13.6 miles. This will be an immense help to the opening up of the mine and of the district behind it.

They have also considered the question of smelting works, and, I understand, have picked upon a site near Coorinjinna Pool at the mouth of the Balla Balla Creek about three miles from the Balla Balla jetty. In this pool there is a good supply of fresh water, said to be never known to dry up, and usually overflowing into the estuary of the creek. The water issues from below a sheet 4 to 10 feet thick of impure limestone of recent age, which here overlies the older slates and schists and extends over a wide area of the coastal plain. Probably the same flow of water could be got in wells nearer the coast, close to the Balla Balla townsite, and in view of the fact that the Coorinjinna Pool is required for stock and is of very great service to the pastoralists travelling sheep and cattle along the coastal stock route—on which it is situated—it would be best to try to obtain a supply for the smelter from wells rather than from the Pool and to keep the works some distance from it, though water could be taken by pipes from it if necessary. A supply of salt water for the water-jackets of blast furnaces can be obtained from the estuary at all times.

Some of the limestone above mentioned is pure enough for smelting use as flux and could be very cheaply obtained at the proposed smelting works site. There is a certain amount of fair oxide of iron flux carrying some copper in the Whim Well Mine itself in the oxidised zone, and I was informed that large quantities of iron ore of good fluxing quality were obtainable in the neighbourhood at low cost. Coke and coal can be landed at Balla Balla fairly cheaply and when the tramway is built the conditions for local smelting should be on the whole very favourable. At present the Whim Well Mine does not produce sufficient sulphide ore for matte smelting, but this will probably be remedied when the lower levels are opened up, and a certain amount of sulphide ore can also be obtained by sea from the mines round Roebourne. Smelting for black copper might have to be carried on for a time until more sulphides are available.

Should the deeper workings of the mine provide a sufficient supply of water for smelting purposes, as well as for concentrating the low-grade sulphides to be expected in depth, or if a good well were obtained near the mine, it seems to me that further consideration might well be given to the question of putting the smelting works on or near the mine, so that the lowest possible grade of ore might be treated with a minimum of handling. With the smelter near the mine the work of the tramway would be much less than if all the ore had to go over it, and there would be a better balance of loading, the matte and copper going down going far to balance the coke and supplies going up, giving approximate equality of loading both ways, a condition favourable for cheap running costs on the tramway. Concentration of all work under the manager's immediate supervision is also an advantage not to be lost sight of.



On the other hand if the Company contemplated buying sulphide ores from the Roebourne, Ashburton, and Derby fields, which could readily be brought to Balla Balla, the smelting site near the coast would clearly have advantages. None of these fields, however, could develop extensively without requiring local smelters of their own, and supplies from them would therefore only be small, and obtainable for no long period.

*The Whim Well East Copper Company, No-Liability, M.Ls. Nos. 66 and 80.*—To the north-east of the Whim Well Company's freehold block are two mineral leases of 15 and 24 acres belonging to the Whim Well East Company, on which work was in progress at the time of my visit. The Whim Well lode is traced to a point close to the western boundary of this property, and I think the lode found in the latter is really a continuation of it, but where seen at the Company's main shaft it is running nearly north and south, the enclosing slate country conforming with it in strike and dip. In some workings a little further east however, the same lode and slates are seen to turn to a nearly east and west course. There may be a fault in the lode between where it is seen in this property and the last outcrop to the east on the Whim Well freehold; if not there seems to be an exceedingly sudden bend in both lode and enclosing strata. The main shaft has been sunk 80 feet, and at the time of my visit crosscutting was in progress from the bottom of it to cut the lode. This has been opened at surface and worked downwards on the underlay, passing through the shaft at a depth of about 35 feet from surface. The lode stuff is 2 to 3 feet wide, composed of iron oxide and kaolin with oxides and carbonates of copper. The manager told me that 20 tons of ore had been shipped, which returned  $10\frac{1}{2}$  per cent. copper, 9ozs. silver per ton, and  $2\frac{1}{2}$ dwts. gold per ton. He had about 3 tons of similar ore bagged on the mine and 3 tons at Balla Balla waiting shipment. Cartage to Balla Balla cost 20s., loading 2s., lighterage 15s., wharfage 2s., and freight to Fremantle 20s. He was using 25 bags to the ton, costing 4s. 6d. per dozen.

The outcrop has not been traced very far in this property, but the lode seems well worth opening up, and by driving east it will soon be seen whether it is extending in that direction.

*Bond's Reward, M.L. 74.*—This lies to the west of the Whim Well Company's shafts above-mentioned. A shaft was being sunk at the time of my visit, which was then down fifty feet in slate country, dipping sharply to the E.N.E. A little further west the dip is quite to the east or even a little south of east. If the Whim Well lode continues to conform with the stratification of the slate there is a strong probability that at this point the workings are entirely in the footwall country, below the lode. The work is proceeding on the theory that the lode is a fissure vein and that it will keep its course westward as last seen in the Whim Well workings,

irrespective of the enclosing strata. It is to be said in favour of this theory that no sign has been seen of the lode outcropping at surface between this shaft and those of the Whim Well mine, as it would if it had bent round sharply conformably with the strata, and in view of the reasonable doubt possible as to the nature of the deposit the enterprise of the owners of this ground in sinking to ascertain the facts by the only satisfactory method—that of actual mining work—is entirely commendable.

*Mons Cupri, M.L. 34.*—This mine was formerly worked by the Balla Balla Copper Mines Company, but has lately been acquired by the Whim Well Copper Mines, Ltd. It is situated on a rounded dome-like hill rising to a height of perhaps 300ft. above the surrounding flat country. The top of the hill is covered with impure brown iron ore, apparently mostly formed by oxidation and alteration by weathering of the underlying rocks. These as previously mentioned are felspathic conglomerates and tufaceous sandstones. The rocks outcropping on the surface just below the ironstone capping of the hill are very much stained and veined with green and blue carbonates of copper, silicate of copper, and oxides of copper and iron, the cupriferous staining being very extensive. When first found it must have offered a most attractive prospect fully justifying the name of Mons Cupri (Hill of Copper) given to it. The copper-bearing material has been cut into nearly all round the hill by series of open cuts and quarries, a large amount of work having been done. There are also two fairly long tunnels from opposite sides of the hill and in one of these a vein traced from the surface workings has been followed downwards by a winze. In the cuts and quarries there is at first sight a very attractive show of copper, green and blue colours appearing on every side, but closer examination soon shows that most of these are due to thin deposits of copper minerals in the joints of the country. Larger veins are not uncommon, however, from which fairly good carbonate and "liver" ore can be picked, but on the whole the mass of cupriferous rock is very poor and highly silicious. I saw no place where there was any definite lode visible, with the doubtful exception of one vein worked downwards by a winze from the open workings on the south side of the hill, and in the winze below the low level tunnel. Even this vein however might well be due to the cupriferous solutions which have stained the higher country finding their way downwards along a fracture somewhat larger and more regular than the small ones in which most of the little veins have been formed. In the low-level tunnel the country rock contained much pyrites, and efflorescences of copper sulphate on the walls showed that even now the metal is travelling through the rock in a state of solution, but I hardly think that the pyrites themselves are sufficiently cupriferous to have been the source of the copper deposits above. It may be that these are due to repeated concentration by superficial agencies of the copper present in small quantities

in the pyrites, but I hardly think that this can be so. It seems to me more likely that the copper has come from a bedded deposit at one time overlying the present surface of the hill and which has been removed by denudation, and that the present ores are derived from it by dissolved copper percolating downwards into the underlying country.

In some of the cuts there are portions of the rock which carry a considerable amount of copper, occasional bunches of very fair carbonate and "liver" ore being obtainable, and the ore-dumps from these workings show a good deal of stuff which would probably be payable if smelted locally on a fairly large scale. I was informed, however, that the samplings of these dumps had been usually disappointing, the assays showing values much less than one would expect from the appearance of the ore. The production from this mine is shown by the foregoing table of copper production of the West Pilbara Goldfield to have been 2,009 tons of ore valued at £12,036.

There is a small round American water-jacket smelter plant on this mine, but it was run for only a very short time, and the slag-dump shows that very little ore could have been treated. Pyrites imported from Spain was used to supply the sulphur required for the matte.

This mine is on the whole of low-grade, but there must be a large total quantity of copper in it, and it does not seem to me to be in any way a hopeless proposition. The richer veins and bunches are in places fairly plentiful, and there are chances of improvement in this respect as work proceeds. Much work can be done cheaply by open quarrying without underground mining, and there is still hope that a more definite lode of ore body may be discovered. If a cheap lixiviation treatment of the low-grade oxide and carbonate ores could be instituted there would be a very large amount of suitable ore readily available. Experiments in this direction seem to me the most hopeful line of action, for if the bulk of the poor rock could be made to cover costs of mining and treating it, the richer veins and bunches obtained in breaking it would probably give a good profit. Valuable information as to the extent of the deposit could most rapidly be obtained by systematic boring with a diamond drill, but a considerable number of bores would be required.

#### MALLINA DISTRICT.

The Mallina Station homestead lies about 13 miles east south-east from Whim Creek on the road to Station Peak, and the old mines are quite close to the homestead, one of the old mining shafts being now the Station well. A large amount of work was done here about 12 years ago by Calvert's Exploration Co., about which very little information is now obtainable. The country is highly plicated schist and sandstone very possibly belonging to the Mosquito Creek beds of the Geological Survey, and the workings are in flat ground. Work has lately been resumed on the northern-



most of a series of parallel quartz reefs, on which were the most extensive of the old workings. These extend along the outcrop of the reef for over 1,200 feet, in a series of costeans and shafts of shallow depth. The course of the lode is about N. 80 degrees W. with underlay about 1 in 5 to the north. Near the east end of the workings there were several large shafts, on one of which there appears to have been winding machinery, and it is said there was also a 5 stamp battery. The workings are not now accessible, but the reef seems to have been a fairly strong one in this part, there being much quartz lying about the dumps—some of it contains a good deal of stibnite. To see if this antimonial ore carried gold I took a sample of it from one of the paddocks, but the assay result was very poor; viz.:—Antimony 5.06 per cent., gold *nil*, silver 1dwt. 20grs. per ton.

At the time of my visit work was proceeding at two of the old prospecting shafts close together near the centre of the outcrop, the western one of which had been equipped with a whip and the eastern with a windlass. Bailing was proceeding vigorously to unwater the shafts and drives therefrom, which are said to be some 400 feet in length. The shafts are 45 feet deep. Unfortunately the water was not got out till two days later, and I could not see the lode in the drives. At the outcrop the lode is seen to be a large reef of quartz 6 to 8 feet wide with well defined walls. The old dumps contain some very fine looking dense solid stibnite (sulphide of antimony) often heavily coated with cervantite (oxide of antimony), and these have recently been partially picked over to obtain antimony ore for shipment. One small parcel was shipped in March, 1907, for sale in England, and by the courtesy of the owners I have been enabled to obtain the following particulars from the account sales.

The parcel consisted of 205 bags, weighing gross 7 tons 2 cwt. 3 qrs. 26 lb., equal to a net dry weight of 6 tons 19 cwt. 2 qrs. 23 lbs. (6.9853 tons). The assay was 36.20 per cent. of metallic antimony. The ore was sold at a market rate (April 1907) of £24 per ton for 50 per cent. ore less 15s. per unit of metal less than 50 per cent., or equal to £13 13s. per ton, but subject to a further discount of  $2\frac{1}{2}$  per cent., which reduced the value realised to £13 6s. 2d. per ton, giving a value for the parcel of £92 19s. 4d. Shipping freight, dock and loading charges, and marine and fire insurance amounted to £14 5s. 10d., equal to £2 0s. 11d. per ton, assays and sampling to £2 17s., or 8s. 2d. per ton, and cablegrams and commission to £4 19s. 2d., or 14s. 2d. per ton, being a total of £22 2s. for these charges, equal to £3 3s. 3d. per ton. The net value realised was therefore £70 17s. 4d., or £10 2s. 11d. per ton. Against this return have, however, to be charged all expenses in this State of picking the ore, bagging it, and forwarding from the mine to Fremantle. No allowance seems to have been made by the smelters for the small amount of gold in the ore.

There was a heap of several tons of picked ore lying on the ground, from which I took a rough grab sample. It returned 44.96 per cent. antimony, gold 4dw. 6grs. per ton, and silver 10dw. 21grs. per ton. The return of antimony was lower than the appearance of the ore would lead one to expect, but the Government Mineralogist and Assayer found on close examination that there was a lot of silica through the masses of stibnite.

It is said that along the drives, which I could not see, there is a large amount of stibnite visible, and that good shipping ore is freely obtainable. The appearance of the old dump seems to confirm this, there being a very considerable amount of antimony ore in it. Probably, as usual with this mineral, it will be found in richer lenses and bunches of greater or less size from which shipping ore can be hand picked, and also scattered through the quartz in such a way as to require concentration to obtain a marketable product. The prospects seem to justify opening this reef again with a view to testing if it is worth working for antimony, which does not seem to have been regarded as worth picking out when the mine was first worked. The market value of antimony has, however, lately dropped to less than half what it was when the above mentioned parcel was sold.

Near the windlass shaft there was an old paddock of quartz, with little antimony in it, which had evidently been put by itself for some purpose. I took a sample of this, hoping to get gold values, but on assay it only returned—gold 13grs. per ton, silver 1dw. 15grs. per ton. From the extent of the old workings it seems fairly presumable that the prospects of gold at first obtained were good enough to induce the owners to persevere for a considerable time with their trial of the mine, but there is no appearance of any large quantity of stone having been crushed. It is unfortunate that all record of the old tests has been so completely lost, and now that the mine is being tried again one of the first things to be done should be a systematic sampling of all accessible parts of the reef both for antimony and gold.

*The Mining Handbook of W.A.* (2nd edition 1895, p. 78), mentions that at Mallina "the gold is associated with sulphide of antimony, and in parts it is very rich, but the portion of the reef which carries much gold is small, although the reef itself is of great size." This emphasises the necessity for very careful sampling to locate the auriferous parts of the reef.

Some 10 to 15 chains south of this lode close to the Mallina homestead the outcrops of three or perhaps four parallel reefs are visible, close to one another. One is a large white outcrop of quartz dipping northerly, in the foot wall of which a shaft has been sunk which is now used as the station well. This is a big lode but very little work has been done on it, so presumably it has been found to be poor. About 70 feet north there is a parallel reef about 2ft.

6in. wide of quartz much iron-stained, on which there are some old shallow workings. South of the well some work has also been done on what seems like a branch from the big reef. I noticed a little antimony in some of the quartz in this. About 200 feet further south is the Stray Shot reef, which however dips somewhat flatly to the southward, its underlay being opposite to that of the other reefs of the series. This reef was small but a good deal of work was done on it, and I was informed that the last crushing from it returned over an ounce of gold to the ton, also that rich specimens from it were sent to the Paris Exhibition. To learn anything now about the value of these reefs it would be necessary to clean out the old workings and thoroughly sample the stone.

Such gold returns from Mallina as have been officially recorded are shown in the foregoing General Table of Gold Production of the West Pilbara Goldfield, but are probably very incomplete. They show 103.60 tons crushed for 102.83 ounces of fine gold.

Mallina is of historical interest as being the locality where gold was first found in the Pilbara fields in 1888 by Mr. James Withnell.

#### TOWRANNA DISTRICT.

The Towranna centre lies about twelve miles southwest of Mallina in dioritic schist country, and has been entirely deserted for some three or four years past. The Government Geologist's report of 16th November, 1906, gives some information about the old mines compiled from the reports of the Inspectors of Mines, from which the following particulars are taken:—

A very noticeable feature of the place is the occurrence of a belt of porphyry running nearly north and south in which the reefs appear to have been more persistent and richer than those found in the schists. Very little alluvial gold was found.

*Yellow Aster, G.M.L. 207.*—This was the principal mine of the district, and had some £13,000 spent on it in development work and in the erection of a 10-head battery and winding and pumping plant. There were some eight shafts sunk, one to about the 100 feet level, and considerable driving done. The reefs ran N.N.W. with easterly underlay, and were 18in. to 30in. thick, traversing the porphyry. From 1897 to 1899 there were crushed 1,000 tons of ore for 875.07ozs. of gold, and a subsequent small crushing in 1901 of 35 tons for 47.69ozs. and cyaniding of the tailings which yielded 231.98ozs., brought the total returns to the end of 1903 to 1,035 tons for 1,154.72ozs.

*Towranna Queen, G.M.L. 271.*—The workings on this lease were on a very flat vein 12 inches wide; 31 tons were crushed for 22.57ozs. of gold.

*Towranna, G.M.L. 204.*—The reef is said to have been 18 inches thick. Crashings are recorded from 1897 to 1900, a total of 848.80 tons returning 895.79ozs. of gold.



*Day Dawn, G.M.L. 87.*—Reef small—20 tons in 1897 gave a return of 15.18ozs. of gold.

*Diamond Jubilee, G.M.L. 101.*—11.00 tons returned 7.22ozs. of gold.

The total officially recorded production of the Towranna centre is 1,934.80 tons crushed for 2,088.26 fine ounces of gold. Several other mines were worked besides those mentioned, but had no recorded crushings.

#### EGINA DISTRICT.

I did not visit this old centre, which is said by the *Mining Handbook of W.A.*, Second Edition, 1895, p. 78, to have had a "rich patch of alluvial workings," the output of which does not appear to have been officially recorded separately. The Egina Copper Mine is, however, shown to have yielded 530 tons of copper ore valued at £6,571.

#### CROYDON DISTRICT.

Between Towranna and Croydon Station the road traverses flat valleys between ridges which appear to be composed of diorites and schists. At Mr. Macrae's Croydon Homestead there is an excellent exposure of conglomerates, grits, and schists, probably of the Archaean "Mosquito Creek" series. The beds strike nearly north and south and dip nearly vertically, and are strongly jointed and often traversed by quartz veins, in which a little gold is stated to have been found. The grits seem to be mainly composed of disintegrated granitic material, and afford fairly good building stone, made use of in the erection of the homestead buildings. This building stone may be very useful in time as the country becomes opened up. Going easterly from the Croydon Station to the Evelyn Copper Mine the country soon changes to diorite and dioritic schists.

*Evelyn Copper Mine, M.L. 31.*—About three miles to the eastward from Croydon Homestead a lode is found striking north 40 degrees east, in laminated greenstone country, on which a good deal of work has been done at one time and another, principally by the British Exploration of Australasia, Ltd., Coy., and which has recently been re-opened. The main shaft is said to be sunk 100 feet, but was full of water to 45 feet when I saw it. A good deal of work has been done from this shaft on a shoot of copper ore which appears to have been about 40 feet long. At the time of my visit a portion of the oxidised ore near the surface which had been left when the mine was formerly worked was being taken out by an open cutting about 15 feet deep. The lode in this showed six to eight feet of ore, mostly oxide of iron and clayey matter, with plentiful large bunches and veins of oxides, carbonates, silicates, and sulphides of copper. Some very good ore was to be seen in the ore heaps, and the manager estimated that he had in bags ready for shipment about 50 tons of ore containing 20-21 per cent. of copper. Various

samples had given two to 14 per cent. of zinc, and up to seven ounces per ton of silver, but no gold. Some carbonate of zinc is visible in the oxidised ore in places, and there is blende below the water level. The manager told me that  $7\frac{1}{2}$  tons of ore had been shipped, and he had about 65 to 70 tons bagged and in the ore heaps. I took a rough grab sample from a few of the ore bags for analysis by the Government Mineralogist and Assayer, who found :—

	per cent.
Moisture at 100°C	3.86
Silica $\text{SiO}_2$	19.45
Alumina $\text{Al}_2\text{O}_3$	3.08
Magnesia $\text{Mgo}$	1.89
Lime $\text{CaO}$	7.04
Iron $\text{Fe}$	20.51
Zinc $\text{Zn}$	1.73
Copper $\text{Cu}$	15.18
Sulphur $\text{S}$	.36
Oxygen, Carbonic Acid, etc., $\text{O}, \text{CO}_2$	26.90
	<hr/> 100.00 <hr/>

Assay on dried ore :—

	per cent.
Copper	15.79
Gold	Minute trace
Silver	44oz. 15 lwt. 3gr. (4756oz) per ton.

This analysis shows the composition of the ore to be excellent for smelting purposes, the gangue being self-fluxing.

The Government Mineralogist also examined a number of pieces of ore from this mine to determine the minerals present, his report being :—"Minerals present are chrysocolla, malachite, cuprite, tile ore, chalcocite, chalcopyrite (little), blende (little), smithsonite (little), quartz, limonite, calcite (thick crusts and veins)." The water shown in the analysis is partly from the chrysocolla, which loses half of its water at 100 deg. C.

Some of the mine assays have shown the ore to contain up to 48 per cent. of copper, some of it being pretty rich copper glance. Below the water level there appears to have been a great deal of iron pyrites and marcasite. The dump of this stuff is said by the manager to contain an average of seven per cent. copper and six per cent. zinc, there being a good deal of blende.

This shoot of ore, though rather short, seems a strong one, and though it has much marcasite in it below the water level which reduces the value there is reason to think that a good deal of this is of secondary formation, and may give place at a little lower depth to pyrite and chalcopyrite. The presence of zinc is a rather serious drawback to the ore from this mine, but it seems worth a more extended trial than has yet been given to it. The work in hand at the time of my visit was simply ore-breaking, no development being in progress, but I understood from the manager that he expected to pump out the shaft shortly. There is a portable multi-tubular boiler on the mine, but it had not been used for some years.

There are about eight other shafts on the lease, but none of these have been successful in getting payable ore. South-west of the main shaft the lode has not been traced beyond the end of the workings on the ore shoot, but to the north-east there is a strong line of brown iron ore outcropping, and some of the shafts sunk have obtained a little copper ore. There seems to me to be a good chance of finding another shoot of ore by prospecting in the vicinity of No. 5 shaft, where the brown iron ore outcrop is largest. The country is diorite schist, fairly easy to work so far as the operations have shown.

The recorded returns from the Evelyn lease are:—To the end of April, 1907, 453.00 tons, value £5,593.

Other leases, now voided, at Croydon are recorded to have produced 40 tons of ore valued at £595.

*Quamby* (M.L. 103, formerly M.L. 47) and *Kopje* (M.L. 105):—About three miles northerly from the Evelyn mine Messrs. Eyre, Gurr, and Roberts have a lode on these leases about two to three feet wide, from which green carbonate ore is being obtained. I had not time to visit this. Some five tons of ore are stated to have been bagged for shipment, of average assay about 26 per cent. copper.

#### STATION PEAK DISTRICT.

From Croydon Station to Station Peak the road traverses mostly plains of granite country coming into diorite hilly ground 4 or 5 miles west of Station Peak. At this centre very little mining work was going on, the principal mine being nearly idle at the time of the visit. There are several known reefs, mostly running more or less east and west in a belt of diorite and diorite schist country which also runs east and west and has quartzite and slate both north and south of it.

*Pilgrim's Rest Mine*, G.M.Ls. 117, 118.—The main workings of this mine have been in a large open cut on the reef, the outcrop of which can be followed for a considerable distance westward nearly along the ridge of a spur from a high hill in that direction. The open cut workings are between three and four hundred feet in length, and the stone has mostly been worked out to the level of a tunnel by which it was brought to the back of a 20-stamp battery. Mr. D. Bull, one of the owners of the mine, informed me that the reef would average about 9 feet in thickness in the ground he had worked, varying from 2 or 3 feet up to 15 or 20 feet, which seemed quite in accordance with the appearance of the worked out ground. The country is diorite schist laminated more or less parallel with the reef, but the latter has smooth walls and often crosses the lamination of the country and so is of the fissure lode type. The stone is a solid bluish quartz often stained with brown oxide of iron and in the deepest workings contains a little copper and arsenical pyrites. The course of the reef is more or less east and west, with underlay



to the south, but it bends towards the east end more to the north-east. There are two or more reefs and some cross reefs connecting them, but my examination of the mine was too short to enable me to give a description of each of these. The outcrop to the westward is somewhat broken, the reef being probably either dislocated by heaves or being a series of lenses of quartz *en echelon*.

To the north-east of the battery a shaft has been sunk 132 ft., cutting the lode 8 feet thick at 100 feet but little work has been done from this. There is also a water shaft about 350 feet south from the battery, sunk to a depth of 105 feet, and provided with pumping appliances.

According to the official returns this mine has produced, to April 30th, 1907, 9,888 tons of ore, returning 9,321.87ozs. of fine gold. The gold has been got by amalgamation alone, the tailings being stacked on the ground for future treatment. It was not possible for me to ascertain the value of these tailings, Mr. Bull informing me that assays he had obtained gave an average of 5 to 6 dwts. of gold per ton, while on the other hand the heap is said to have been sampled more than once by would-be buyers who declared that their results were only 2 to 3 dwts. per ton. Taking into account the returns obtained by amalgamation and the nature of the stone it seems probable that the tailings still contain enough gold to be worth cyaniding, and if this is shown to be true by systematic sampling and assaying of the heap, they will constitute an important asset to the mine owners.

The mine has been worked by the owners in accordance with the exigencies of their position in what can only be termed a hand-to-mouth manner, and equipped with the 20-head battery and other machinery upon it from time to time as funds were available from the crushings. The owners have probably done as well as most other people would do in the same circumstances, but have not been able to develop the mine in the systematic and extensive manner required for a reef of this magnitude. It is a case where a fair amount of capital expended in development and equipment is required in order to enable proper and economical mining and milling work to be done, and on the record of the mine there seems great likelihood that if it were given such development it would become a large and important concern. It seemed to me a proposition very well worthy of the attention of investors. In saying this however, I must disclaim putting forward this opinion as anything more than the favourable impression received after seeing parts of the mine and learning its recorded output, my visit having been much too short to enable any sampling to be done of the ore in sight or even to visit the deeper workings. Anyone seriously intending to invest in the mine would require to have it systematically examined on his own behalf to find out what quantities and values of ore are now in sight, and judge for himself whether the future output is likely to

equal the past production in average value of the ore. Firewood and mining timber are not very easy to get at Station Peak, the former costing 30s. per cord and likely to rise to 35s. The local timber is not much good for mining purposes, straight logs long enough for underground work being hard to obtain.

Some gold is said to have been got to the west of the Pilgrim's Rest mine in the outcrop of its reef in that direction, and also in the Pilgrim's Progress reef, which is a parallel ore body lying about 5 chains to the south of the Pilgrim's Rest line. Mr. D. Bull informed me that some gold had also been got to the eastward on a reef supposed to be the eastward continuation of the Pilgrim's Rest reef.

*Galena Lode.*—Mr. D. Bull informed me that there was a lode carrying a good deal of galena not very far from the Pilgrim's Rest mine, but time did not permit of its being visited.

*Armour's P.A.*—A short distance east of the Pilgrim's Rest lease a little work was going on at the time of our visit upon a small cross lode, about 18 inches thick. The quartz was of bluish colour and showed gold freely, and contained a little galena and oxides and carbonates of copper. A small amount of good stone had been raised.

#### HONG KONG.

This field lies about 5 miles S.W. from Station Peak, and was quite deserted when our party passed through it, though a small party of men had been working very recently. They were on the "Three Prodigals" lease, G.M.L. 134, formerly known as the "Queen Victoria," G.M.L. 97, which included part of the still earlier "Hong-Kong," G.M.L. 66. They had a two-stamp light prospecting battery driven by a small engine and boiler with which they crushed to 30th April, 1907, 10.35 tons of quartz for a return of 19.22ozs. of fine gold. There was also an old 2-stamp Tremain Mill on the ground and a good rock-breaker. A good deal of work had been done, most of it some years ago by an English company. The country is diorite schist lying at the foot of a large hill of laminated quartzite.

About a mile to the north of these workings are some other old ones which were fairly extensive, there being two or three shafts and several cuts into the reefs. There is said to have been once a 10-head battery at this spot. These workings appear to be those of the old Britannia mine (G.M.L. 82, formerly Empress, G.M.L. 105). The following information about this centre is taken from the report by the Government Geologist, dated 16th November, 1906:—

*Hong-Kong, G.M.L. 66.*—Two shafts were sunk, the southern one 70 feet deep on the underlay of a reef striking N. and S. and underlaying east about 1 in 1. At 55 feet levels were driven 30 feet north and the same distance south. The reef dipped more

steeply (70deg.) below this level and was small in size (7 inches). It is stated that the stone from the shaft gave a return of 3ozs. per ton from 15 tons crushed and 10 tons from the drives averaged about 2ozs. The quartz was dense and hard and contained quantities of iron and copper pyrites with a little galena. The second shaft was near the northern boundary of the lease and was sunk 38 feet on the underlay. The recorded production of the Queen Victoria reefs is 89 tons crushed for 82.67ozs. of fine gold.

*Here's Luck, G.M.L. 62.*—This adjoins the Hong-Kong lease on its north end. An underlay shaft was sunk on an irregular reef, 4 to 18 inches thick, from which about 15 tons of stone were raised, but the returns from the crushing do not appear to have been recorded.

*European, G.M.L. 63, Pinyang, G.M.L. 72, and Foochow G.M.L. 65.*—On these leases a little work has been done, but the only crushing of which there is information seems to be one from the Foochow of 25 tons from an open cut and shaft which returned 83ozs. of gold. (This is not among the official returns.)

*Empress, G.M.L. 105, formerly Britannia, G.M.L. 82.*—This was on a small reef about 8 inches thick, running N.W. and S.E. and nearly vertical in dip. A shaft was sunk 55 feet, 226 tons crushed, mostly in 1899 and 1900, yielded 335.90ozs. of fine gold, or at the rate of 1.48ozs. per ton.

*Break of Morn, G.M.L. 73.*—Reef N. and S., dip east 75deg., very small (2 inches) at surface. Two underlay shafts have been sunk about 50 feet apart and connected at the 30ft. level. The reef was faulted in the northern shaft at 25 feet and was two feet thick when found again. 16 tons crushed (prior to 1897) yielded 23.88ozs. of fine gold.

*Mystery, G.M.L. 93.*—The Break of Morn reef is traced into this ground, and a shaft has been sunk on the underlay 40 feet, the reef being 2 inches thick at surface and 18 inches at the bottom of the shaft.

*Sundry Claims* at Hong Kong are reported to have returned 24.57ozs. gold from alluvial gold and 9 tons of ore crushed, the total for the district to April 30th, 1907, being thereby brought to 486.24 ounces of fine gold from 350.35 tons.

The returns from Hong-Kong centre are shown in the General Table of the Gold Production of the West Pilbara field previously given.

#### PILBARA.

The Gold Pilbara leases lie about three miles south-south-east from Hong-Kong, and at the time of our visit were quite deserted, the only miners in the district being alluvial workers, of whom there were said to be about 25 scattered round the neighbourhood. There has been a good deal of alluvial gold got in this



vicinity, and many men who have worked here return from time to time to try their fortune again. On the south side of the field granite comes in, and there is a little alluvial tin ore to be got, but most of the old leases were on diorite schist and laminated quartzite country. The latter is very prominent, and is well seen in the saddle, where the road to Hong-Kong crosses the Black Gin's range, a little distance from Pilbara township. Here the quartzite ridge is seen to contain several strong veins of reef quartz up to two feet thick, running north 65deg. east, and underlaying to the north-west, some of which seemed worth testing for gold. The laminated quartzite has every appearance of being a much silicified sheared zone in the surrounding dioritic country.

*Hidden Treasure, G.M.L. 186 now 25.*—Close to the township there has been a good deal of work done on a large outcrop of quartz, traceable for a considerable distance along the crown of a low ridge running north-east and south-west. This line of quartz is said to run south-west for over two miles to a large white quartz hill, which is a very prominent feature in the landscape. The country is diorite schist, laminated parallel with the reef. Several cuttings into the outcrop have been made, but are now much filled up. I understand that they showed the reef to be much smaller than the big masses of quartz at surface would lead one to expect, these masses being often portion of the reef outcrop fallen flat. Some rich stone is said to have been got in the reef, and some crushing was done with a 5-head battery, which has been removed, but after what was evidently a very short trial the work was abandoned. There is a large amount of quartz available if further testing should show that the reef is treatable in bulk, but the presumption is that it was too poor. There is no official record of any crushings from this lease.

The following information is extracted from the Government Geologist's report of 16th November, 1906 :—

The mining centre of Pilbara appears to have been discovered in July, 1888, and the gullies and flats have been very extensively worked for alluvial gold, some thousands of ounces, chiefly slugs, nuggets, and coarse gold having been obtained, much of which was in all probability never officially reported to the Government. The occurrence of veins of intrusive granite in the district should encourage search for tin, the prevailing geological conditions being identical with those of the tin-bearing centres of the Pilbara Goldfield.

*John Bull, G.M.L. 79.*—On this lease there was a shaft sunk 80 feet on a vein of quartz six to 12 inches thick, carrying sulphides of iron, lead and copper. A trial crushing of five tons is said to have yielded 26½ozs. of gold per ton. A copious supply of water is said to have been got in the shaft. The recorded output from this lease is 233.72 ounces of fine gold from 24 tons of stone.

*Queen Mab, G.M.L. 45 (247).*—There are two lines of reef in this lease, both of which were worked, but the returns seem to have been poor, 100 tons of stone yielding only 28.51ozs. of fine gold.

*Esmeralda, G.M.L. 34 (205).*—There is a strong reef, three feet to eight feet thick in this lease running north-north-east, on which considerable open cut work has been done. Some rich specimen patches are said to have been obtained, but no returns are in the official records.

*Compadre, G.M.L. 29 (200).*—Two parallel lines of reef were worked on this lease, showing strong bodies of quartz. On one an underlay shaft was sunk 90 feet.

*Pioneer Extended, G.M.L. 46 (248), Pioneer, G.M.L. 28 (199).*—A little work has been done on quartz veins in these leases, yielding some rich specimen stone. The gullies on them are stated to have yielded some of the richest results in the district to the prospectors; 24 tons of quartz from these leases are officially recorded as having produced 31.19 ozs. of fine gold.

The official returns from the Pilbarra centre give to 30th April, 1907, a yield of 293.42ozs. of fine gold from 148 tons of stone crushed. The alluvial gold has not been separately recorded, being included, so far as known, in the 3,303.03 ozs. of fine gold of alluvial origin shown in the foregoing table as obtained from the West Pilbara Goldfield generally.

#### WODGINA DISTRICT.

The road from Pilbara to Wodgina is mostly over flat granite country, with frequent rugged hills of granite rising from the plains like islands from the sea. The Wodgina hills are a larger island or chain of islands running north-north-easterly for a distance of over 20 miles and rising steeply to a height of about 700 feet above the surrounding plains, but differ from the smaller hills in being mainly composed of greenstones, metamorphic, and dioritic schists, slates, and ferruginous quartzites, under which the granite has intruded, and through which it has penetrated in the form of numerous dykes of pegmatitic character. The geological structure of this district is fully described, with illustrative maps and sections, in Geological Survey Bulletin No. 23, to which reference must be made for details. The most important feature from the industrial point of view is that the protruded pegmatitic dykes which break through the older Archæan schists and quartzites are frequently themselves stanniferous to a payable degree, and seem besides to have caused formation of true lodes, carrying often rich tin ore, in the superincumbent schists. There is a very strong similarity in this respect to the mode of occurrence of the tin ore at the celebrated Mt. Bischoff tin mine in Tasmania, of which I have personal knowledge, where the ore has been deposited in the vicinity of the contact of an intrusion of quartz and topaz por-

phyry with the very ancient metamorphic sandstones and slates through which it breaks, occurring in the porphyry itself, in crevices and seams in the surrounding sandstone, in true lodes and veins, and especially along the actual contact of the intrusive and older rocks. The intrusions at Wodgina appear to be much more extensive than those at Mt. Bischoff, and all conditions seem very favourable for a similar deposit of tin ore occurring. Very heavy and rich lumps of cassiterite, 50, 60, and even 80lbs. in weight have been found in the alluvial workings, and already in some of the lodes several pieces exceeding those in size have been obtained, besides rich lumpy ore in very valuable quantities. It may be said that these discoveries already prove that the conditions of deposition must have been favourable for formation of rich tin ores in some of the mines at Wodgina, and as this is the case we have much reason to expect good discoveries as the workings open up the deposits more extensively.

*Mt. Cassiterite, M.L. 84.*—The greater portion of this lease lies on the Western slope of the hill, the ground being very steep. The country is slate and schist, with numerous outcrops of jasperoid quartzite. These often contain quartz of lode character, and much brown oxide of iron, and frequently show brecciated and contorted structure; as explained previously in the geological sketch, they were most probably beds of the slate country originally, which have been much fractured by earth movements, allowing the fractured zone to come under the action of highly heated waters escaping from the heated interior, which have removed all soluble material and replaced it with silica. The brown iron ore so often seen in the outcrops is probably partly due to superficial charging of the quartzite with oxide of iron by chemical interchange of its constituents with iron in solution in the surface waters, and partly to oxidation of contained pyrites. The great significance of these quartzites lies in the proof which they afford of the extensive action in the districts where they occur of the same agencies which are now generally believed to form mineral lodes, and it is very possible that there may be a close connection between their formation and that of the metalliferous lodes of the locality. In this Wodgina district where the intrusion of large granitic masses through the older slates seem without doubt to be the cause of the tin-bearing lodes being formed, it seems reasonable to suppose that the silicification of the country to quartzite was also accomplished from the same cause. The belts of ferruginous quartzite would then have to be regarded as large "lode formations" in favourable portions of which metallic ores might be expected to occur. The main part of the hill at Wodgina on which are the tin mines is on a belt of quartzitic country of this sort, running north-easterly, between greenstones on the north-west side and slates and schists on the south-east side, and this belt is greatly penetrated by numerous pegmatite dykes.



Along the top of the ridge of the hill, and especially round the cairn near the south-west corner of the Tinstone lease (M.L. 89), there is a large capping of brown iron oxide, which seemed to me to partake more of the character of lode "gossan" than of the "laterite" deposits found capping so many hills in this State. Remembering the occurrence of tin ore in the huge brown iron ore deposit of the "Brown Face" at Mt. Bischoff, for many years the mainstay of the Mt. Bischoff mine, this brown iron ore seems to me to be worth very careful prospecting for tin.

On the Mt. Cassiterite lease good alluvial tin ore was found in Ogilvie's gully, and there were also alluvial workings west of the western boundary in a gully running up into the south-west corner of the lease. In this corner a little work has been done on some tin-bearing veins close to a pegmatite dyke—some good tin ore was obtained, associated with black tourmaline and green pinguite, but the ground is not sufficiently opened to give a good view of the occurrence. The main workings are on a lode in the north-west corner of the lease. Here two tunnels have been driven from opposite sides of the ridge on the course of the lode—which runs nearly east and west—to form the top level when connected, and on the west side another tunnel has been put in lower down the hill. The lode is a true fissure vein from two feet to as much as 10 feet wide, with smooth walls, cutting distinctly across the stratification of the country. The veins stuff is mainly quartz, but there is much soft lode matter as well, mostly chlorite and kaolin, in which the best ore has been found. The richness of this ore will be seen from the fact that 41 tons of clean tin ore are stated by the owners to have been obtained from this lode without the aid of machinery by hand-picking and the following process. The soft lodestuff is thrown upon a round sieve worked by hand, on which it is shaken with a motion similar to that used in panning off alluvial gravel in washing for gold or tin with the ordinary prospector's dish, but in this case the material is dry. The fine stuff goes through the sieve, and the lighter part of the coarse material comes to the top and is allowed to escape over the side of the sieve. After working for a little time there is a quantity of coarse lumpy tin ore left on the sieve, which is then hand-picked and bagged. The finer material passing the sieves might be treated on a dry-blowing "shaker" to obtain the finer tin ore, but at the time I saw the work in progress only the sieve was being used. The extreme roughness of the treatment is obvious, and the tailings still contain much ore, and are being saved for washing later on.

The owners have the erection of a dressing plant under consideration, and have lately been successful in finding a good supply of water by boring in the valley of McCarthy's Creek, a little distance above the township. At present the ore is sent down from the hill by means of a "flying-fox," or aerial tramway; and timber for the mine is taken up the same way. The mine will be workable from

tunnels for a long time, and is at present one of much promise. It has paid its way out of tin produced, even with the primitive method of ore dressing above described. About 23 men were being constantly employed in it at the time of our visit, and good development work was being done, the underground workings being now of some considerable extent. The official record of production from this mine to 30th April, 1907, is 55.92 tons of black tin ore valued at £6,048 (see table below).

*Tinstone, M.L. 89.*—This lease is on the eastern slope of the hills, and though it adjoins the south-east corner of the Mt. Cassiterite lease, the ground is so steep and rough that if the owners of the latter mine put up their proposed battery near the township on the west side of the ridge, ore from the Tinstone would have to be carted from the east side right round the north end of the hill, a distance of some seven miles, or else carried over by an aerial tramway to reach it. Some alluvial tin ore has been got in the gullies on this lease. The large outcrop of brown iron ore near the south-west angle of this lease has been already mentioned above: it is a hard gossan with frequent veins of quartz traversing it, and seemed to me very like the capping of what may prove to be a very large "formation." A little distance down the hill I noticed a considerable outcrop of purplish-coloured lepidolite-rock, which seemed to be of the nature of a vein or dyke, and is doubtless closely connected with the pegmatite dykes. This rock occurs in several other parts of the Wodgina district in much the same way, and may be regarded as a very favourable indication for tin, the association of lithia mica with tin ores having been often noted in many tinfields. The lepidolite rock is in considerable quantity, and seems to be often fairly pure, so may become of some value in the future as a source of lithia, for which purpose this mineral has a fair market value, varying with the amount of lithia it contains. Its value is, however, too low for shipment under present conditions of transport.

Two tunnels have been driven on a lode running about north-east and south-west, and connected by a rise. The country is softish laminated schist, the lode cutting the lamination obliquely, and shows well smoothed walls. It has considerable underlay, and consists of soft kaolinic matter with quartz chlorite and tourmaline, often containing rich coarse tin ore very similar to that above described in the Mt. Cassiterite lode, and which is separated in the same crude manner. About 18 tons of ore are said to have been shipped from the workings, some of which does not yet appear to have been included in the returns to the Mines Department. The lode seems well worth opening up on a more extensive scale than has yet been attempted.

The official returns show an output from this lease of 10.70 tons of tin ore valued at £1,070.

*Commonwealth, M.L. 85.*—A short distance west of the Tinstone workings another outcrop of lepidolite is seen, associated with quartz, and further west still are some workings on a lode of kaolin and chloritic matter containing some very nice tin ore in parts. The workings are not yet at all extensive, and very little can be said about them. The recorded returns from this lease are 2.95 tons of black tin ore, valued at £348.

*Y.Z., M.L. 90.*—This lease lies north of the Tinstone, and some alluvial work has been done in a gully running northward through it. The brown iron ore capping shown strongly on the top of an east and west spur towards the south boundary, and below this on the north side of the spur a big vein of kaolin, quartz, and felspar has been followed, dipping very flatly under the capping. The hanging wall of this lode is well smoothed, but the footwall seems to emerge into kaolinised pegmatite, the veins being very probably on the upper surface of a dyke of this rock. A winze was being sunk in the pegmatite when I visited the mine, and was down 20 feet in it, the kaolinised matter carrying a little tin ore disseminated through it all the way down. This occurrence of tin ore through the mass of the pegmatite dyke is noteworthy, as it will probably recur frequently in the field, and these dykes are very numerous. Portions of them may, therefore, turn out to be worth working. There is no recorded output from this lease.

*May and Dawson's, M.L. 110.*—Considerable alluvial working has been done in a gully running north-westerly through this lease. At the head of this gully are some workings on two lodes which have yielded some very good tin ore. The ore is mostly in soft chloritic lodestuff as at the Mt. Cassiterite and Tinstone mines, but tin is also seen in some of the hard quartz. The lode seems to run about east-north-east, with southerly underlay. A shaft has been sunk 60 feet, and a cross-cut put in from it to the northern lode, which is here a fairly large body of quartz and chlorite. There seems to be a large ferruginous quartzite "formation" running with the lode, but there is also another one out-cropping very strongly on the steep slope to the west, which appears to run off at an angle to it. It is by no means clear yet how many lodes there are, and what are their relations to one another and to the ferruginous quartzites. The rock all about the workings is greatly veined with quartz, and much silicified in places, and a great deal of it might well be regarded as "lode formation" rather than "country." A good deal of mining will have to be done before the nature of this ore occurrence can be fully understood. Messrs. May and Dawson have had some very good ore, having obtained about 20 tons of clean tin oxide by handpicking and sieving. The ore is sent down from the mine by a "flying fox" to McCarthy's Creek, where it is sieved and some of it washed in a puddle. Some of the ore, however, is pretty hard, and will require crushing to liberate the tin. The output of this mine has either not been sent in to the Mines Department, or is included in the returns from Sundry Claims in the following table.



## WODGINA

*Quantity and Value of Black Tin Ore and Tantalite*

No. of Leas- or Claim.	Name of Lease or Owner.	1905.				1906.			
		Lode.	Stream.	Total.	Value.	Lode.	Stream.	Total.	Value.
		Tons.	Tons.	Tons.	£	Tons.	Tons.	Tons.	£
BLACK									
77	Stannum .. ..	..	4.35	4.35	255	..	1.75	1.75	206
84	Mount Cassiterite .. ..	..	13.85	13.85	1,132	23.42	..	23.42	2,678
85	Commonwealth .. ..	..	..	..	..	2.95	..	2.95	348
88	Chamberlain .. ..	..	..	..	..	.35	..	.35	60
89	Tinstone .. ..	..	..	..	..	3.60	..	3.60	360
93	Mount Cassiterite North .. ..	..	..	..	..	6.12	..	6.12	643
	Sundry Claims .. ..	..	13.25	13.25	1,075	.15	6.45	6.60	662
	Mullner's Claims .. ..	..	..	..	..	..	..	..	..
	Total .. ..	..	31.45	31.45	2,462	36.59	8.20	44.79	4,963
T A N T A -									
86-87	H. M. and Anchorite .. ..	..	26.00	26.00	3,425	1.80	6.30	8.10	2,020
	Sundry Claims .. ..	..	44.95	44.95	5,500	..	5.65	5.65	530
	District Generally .. ..	..	..	..	..	..	.90	.90	94
	Total .. ..	..	70.95	70.95	8,925	1.80	12.85	14.65	2,644

## DISTRICT.

*produced as Officially Reported to the Department of Mines.*

1907 to April 30th.				Total.			
Lode.	Stream.	Total.	Value.	Lode.	Stream.	Total.	Value.
Tons.	Tons.	Tons.	£	Tons.	Tons.	Tons.	£
TIN ORE.							
..	..	..	..	..	6.10	6.10	461
18.65	..	18.65	2,238	42.07	13.85	55.92	6,048
..	..	..	..	2.95	..	2.95	348
..	..	..	..	.35	..	.35	60
7.10	..	7.10	710	10.70	..	10.70	1,070
..	..	..	..	6.12	..	6.12	643
..	10.47	10.47	967	.15	30.17	30.32	2,710
.63	.63	1.26	126	.63	.63	1.26	126
26.38	11.10	37.48	4,041	62.97	50.75	113.72	11,466
LITE.							
..	..	..	..	1.80	32.30	34.10	5,445
..	..	..	..	..	50.60	50.60	6,030
..	..	..	..	..	.90	.90	94
..	..	..	..	1.80	83.80	85.60	11,569

*Anchorite*, M.L. 87, and *H.M.*, M.L. 86.—On these leases a very considerable amount of tantalite has been obtained by ground sluicing, water being pumped on to the ground from a well near McCarthy's Creek, by means of a boiler and pump. The country is mainly schistose diorite, but both leases are traversed by a large dyke of pegmatitic granite running about north and south, which is the matrix of the tantalite. In places the dyke is almost entirely composed of albite (soda-felspar) while elsewhere it is very largely quartz. An open cut in the southern part of lease No. 86 shows two dykes of albite with fine-grained granitic rock between them as if the albite had separated out on the sides of the granitic intrusion. Tantalite was very freely visible in the albite, in coarse pieces, often up to many pounds in weight. Some very heavy lumps have been obtained, one weighing about 5ewt., evidently derived from the weathering down of the pegmatite. Towards the north end of the lease there is another set of workings where tantalite in fair quantity has been got in a big outcrop of quartz and felspar. A little lepidolite rock is seen also in the vicinity.

The quantity of tantalite reported from these leases is 34.10 tons of nominal value £5,445, but most of the 50.60 tons shown in the foregoing table as from Sundry Claims was also taken from alluvial workings on the same ground. The actual selling prices in Europe varied a good deal, and some of the shipment is said to be yet stored in London without having been placed on the market. These mines were worked energetically for a little time while there was a market for the tantalite, but very soon consumers' stocks were filled, and the mineral could not be sold. There are said to be some 10 tons of the ore belonging to the lessees, and rather more belonging to alluvial workers still on the leases bagged ready for shipment when there is a price to be had for it.

The industrial uses of tantalite are at present very limited, and the demand for the mineral is therefore small, but metallic tantalum has some very remarkable properties which will doubtless lead to its more extensive use as time goes on. The deposit at Wodgina seems to be one of the most extensive discoveries of the mineral ever made, and will doubtless be worked as the demand for the metal becomes established. The ore in the solid albite rock would require dressing to separate it from the gangue, by processes quite similar to those used in concentrating tin and wolfram ores.

It is somewhat remarkable and very fortunate that the tantalite on these leases has been very free from tin ore, and that the tin-bearing lodes of this district have hitherto been very free from tantalite, as the separation of the two minerals is impossible by ordinary washing processes and difficult in the metallurgical treatment.

*Stannum*, M.L. 77.—The *Stannum* leases are about 8 miles S.W. of the Wodgina group above described, and were deserted at the time of our visit. They are near the head of a large gully which



comes out on the west side of the range, by going up which they may be reached with carts or other vehicles. There is a great deal of the metamorphic quartzite country in the vicinity, together with massive and schistose greenstones, through which have been intruded masses of porphyry and felsite of considerable extent. Some of the felsite is schistose, very possibly from the same causes which have caused lamination of the greenstones. There are also pegmatite dykes similar to those at Wodgina penetrating these older rocks; and the tin ores are in close connection with these.

Some alluvial workings have been made in the gully in the N.W. angle of the Stannum lease, and several shallow cuts and shafts have also been excavated on veins carrying tin ore, on the hillside to the south of these. There seem to be several rather flat-lying veins of small thickness cutting through the felsite and greenstone. They consist of quartz, silvery mica, feldspar, and purplish lepidolite and carry some very nice tin ore, but seem more likely to be small pegmatitic dykes than true lodes. If they were a little larger they would probably be worth working, but I am afraid those I saw are rather too small to be payable. The matrix is pretty hard, and would require crushing in order to liberate the tin ore. The Government Geologist's map of the Stannum tinfield (Geological Survey Bulletin No. 23) shows a long pegmatite dyke running south from the above workings, and prospecting along this would be well worth doing.

The output of tin ore recorded from the Stannum group of leases is 6.10 tons valued at £461.

*Other Tin Discoveries.*—The Government Geologist's report (Geological Survey Bulletin No. 23) mentions several other tin discoveries in the Wodgina district, which I did not visit, but so far as I could learn none of these have had much work done upon them since he described them. Close to the road from Wodgina to Port Hedland about a mile from the township I noticed an outcrop of quartz and lepidolite on which a little work had been done, and which was stated to contain some tin ore. It seemed worth opening up more thoroughly, being quite similar to others of the tin-bearing pegmatitic dykes near the township.

The discovery of tantalum minerals and tin ore at Mt. York, 20 miles N.E. of Wodgina, referred to in the Government Geologist's report, is worth bearing in mind when considering the Wodgina district, as showing that the stanniferous area is probably an extensive one. Though time did not permit a visit to the Mt. Francisco district about 26 miles south of Wodgina, information obtained at the latter place from the prospectors, and specimens seen, showed that good tin ore had been got there also, and good specimens were also shown us from Sifflet's P.A., between Wodgina and Mt. Francisco. The ore in both these cases was enclosed in hard lode-matter of granitic structure which would require crushing in order that the tin ore might be liberated.

Though much of the soft lodestuff in this field can be treated by puddling without crushing, there is harder material as well in most of the lodes which requires crushing to set free the oxide of tin. A crushing and dressing mill is therefore very much required in the district. It is probable that the Mt. Cassiterite Co. will put up machinery for this purpose before long, on the western side of the hill, but owing to the steepness of the intervening country this mill will not be easily accessible from the mines on the eastern side, for which a battery near the Government well on that side would be much more convenient. This site would also be much more accessible for prospectors sending in ore from Mt. York and Mt. Francisco. Recent boring has shown that good supplies of water can be got on either side of the hill. Firewood is obtainable more easily on the eastern side than on the western, there being a fair amount of river gum timber on the flats of the Western Turner River.

Carriage of ore and stores to and from Port Hedland, a distance of 75 miles, costs £8 a ton. Mining timber is scarce and dear, costing about 6d. per lineal foot.

#### WODGINA TO TAMBOURAH.

The road from Wodgina towards Tainbourah and Western Shaw goes easterly for 10 or 12 miles over flat granite plains, towards the high rough country lying between Lalla Rookh and Marble Bar, and then turns south-south-eastward, still over granite country, keeping a few miles west of the hilly region, to a short distance south of the Woodstock Station, where it turns into the rougher country and crosses through it into the basin of the Shaw River. This part of the hilly country is mostly dioritic and metamorphic schist and quartzite, with frequent granitic intrusions. The ferruginous quartzites seem to be usually on or close to the contact of the schists with the granite.

At Mr. Pead's Woodstock Station we were shown some fair samples of chrysotile asbestos from the Pilbara Asbestos Co's. discovery, about 25 miles to the north-east, and some copper ore from the hills about 4 miles from the homestead, but we had no opportunity of visiting these finds. The asbestos discoveries have since been visited by Mr. P. C. Riches, Acting Inspector of Mines, whose report upon them is quoted later on. The copper ore was mostly green carbonate of copper. Good "tile ore," oxide of copper, was also shown, obtained from a lode at Tambourah.

#### TAMBOURAH.

This old mining centre has been quite deserted for some years so far as any serious work is concerned. It is fully described in Geological Survey Bulletin No. 23 with the aid of a geological map showing the lodes and country. The reefs are seen therefrom to form a group of parallel veins running slightly east

of north parallel with the lamination of the enclosing country and dipping at high angles to the eastward. The veins are numerous and some of them persistent for long distances, but mostly small. They are roughly parallel to the contact between the schistose greenstone country in which most of them occur and the intrusive granite on the west side of the field, but the latter also sends intrusions into the greenstone and encloses numerous detached masses of it, and some of the reefs are in the granite. The Government Geologist draws special attention to the fact that many of the reefs traverse both greenstone and granite country indiscriminately and "are likely to be as persistent in depth as deposits of the kind can ever be, and they are not liable to be cut off by the granite as might have been the case had the formation of the reefs preceded the intrusion thereof." The reefs seem to have carried a good deal of iron and copper pyrites, and to have gone down strongly into the hard country enclosing them, but all the workings were of small depth. There was a 10-head battery on the field which has been removed, and a rusty Tremain Mill still is standing on the old Tambourah King lease.

The following table is taken from the Government Geologist's report in Geological Survey Bulletin No. 23 :—

*Synoptical Table showing the Yield of the Tambourah Reefs up to the end of 1905.*

Name of Reef.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Brilliant	35·00	21·60	·61
Federal	11·00	15·25	1·38
Kirkpatrick	88·00	208·50	2·36
Kushmattie	140·50	271·65	1·22
Old Australian	5·50	70·10	1·36
P.A.	...	*	
Quartz Claim 146	...	+ 43·71	
Sundry Claims	639·25	‡ 1,264·91	1·42
Tambourah King	86·00	154·00	1·79
Tambourah United §	34·00	37·68	1·10
Western Chief	654·00	763·90	1·16
Western Chief No. 18	102·00	249·31	1·16
World's Fair	412·00	505·60	1·22
Total	2,253·25	3,606·21	1·60

\* Returns probably included under the Western Chief Mine. † Dollied and specimens. ‡ Includes 20 ozs. of dollied and specimens and 333·71 ozs. of alluvial. § Exact locality unknown. || Includes 130·14 ozs. from tailings.

The smallness of the reefs and the hardness of the enclosing country were probably the principal causes of the abandonment of this field. The average value shown by the returns is fairly good, though below the general average of the Pilbara fields, and, under more favourable working conditions, there seems reasonable hope that this district might yet be resuscitated.



## WESTERN SHAW.

Our party was not able to visit the Western Shaw field, which lies about five miles south-east of Tambourah, and, like it, has been deserted for some years past. The Government Geologist's report (Geological Survey Bulletin No. 23) shows it to be very similar to the Warrawoona field in structure. A large amount of alluvial gold is believed to have been won by dryblowers soon after the first rush in 1891. There are several well defined quartz reefs of considerable length, conforming with the foliation of the enclosing schists.

*Synoptical Table of the Gold Yield of the Western Shaw Reefs.**(From Geological Survey, Bulletin No. 23.)*

Name of Reef,	Ore crushed.	Gold therefrom,	Rate per ton.
	tons.	ozs.	ozs.
Imperial Leases ... ..	1,221'00	1,146'29	'91
Trafalgar ... ..	30'00	90'00	3'00
Total ... ..	1,251'00	1,236'29	'98

The Government Geologist states that there is very little firewood within the vicinity of the mines, whilst timber for mining and building purposes would have to be carted at least 20 miles.

## TAMBOURAH TO COOGLEGONG.

Going from Tambourah eastward to Hillside Station the road soon leaves the belt of schist and quartzite country and comes on to granite again. On the contact there is a large development of quartz and jasperoid quartzite, and the granite for a time shows a rough lamination parallel to that of the schists. The most prominent features in this part of the journey are two huge dykes of diabase, the Eastern one of which forms the Black Range. This extends in a north-north-easterly direction, in almost a straight line for about 25 miles, as a rugged ridge rising abruptly from the granite plains and covered with large rough blocks of black stone, bare of vegetation. It is cut right through at Hillside Station by the Shaw River, where it is clearly seen to be a coarsely crystalline quartz diabase dyke breaking through the granite country. The western dyke is not quite so prominent though seemingly equally strong, and lies about four miles west of the Black Range. From Hillside Station the road runs northward, still over granite country, to Cooglegong.

## COOGLEGONG AND SHAW TINFIELD.

The Cooglegong and Shaw Tinfields occupy a very extensive area of country, scattered widely over which are numerous alluvial workings, mostly very shallow, which at present

give employment to about 125 men. At the Cooglegong centre the workings are on watercourses running into the Cooglegong Creek. Roberts' claim, which was visited, is said to be a characteristic example of the ordinary occurrence of the tin. The ground was about six feet deep, with about a foot of rather angular quartz and felspar "wash" on the bottom, containing a very fair amount of somewhat coarse subangular tin ore. The more leamy surface stuff also contains a little fine tin ore. The surface layer is often richer, through concentration of the ore, owing to gradual washing away of the lighter soil, and a good deal of surface ground has therefore been worked by dry-blowers who have not attempted to sink for deeper deposits. The deeper leads on the granite bottom, like those at Moolyella, belong to a time when the watercourses had cut down into the bedrock—since then there has been a good deal of filling up of these older channels, and the present watercourses often run above them. No really deep alluvial ground has yet been found, but the presence of buried leads below the existing watercourses points to their discovery being possible in any of the larger alluvial flats. The surface tin-bearing soil is mostly worked by dry-blowing, but the more clayey stuff from the leads has usually been treated by puddling.

Near the 2-Mile Well there is a good deal of dark-coloured mica schist, striking north-north-east and south-south-west which seems to be resting on the granite, but is probably portion of an older rock under which the granite has been intruded. Penetrating this schist there are several veins of felspar and quartz carrying tin ore. A little work has been done on some of these "lodes" at a point about a mile north-east from the well. Fine, small parallel veins up to 12 inches thick are seen lying flatly one above the other in a width of about 100 feet, some of them showing enough tin ore to be payable if they were a little larger in size. The felspar is albite, as in the very similar case of Thomas' lode at Moolyella, and the tantalite lode at Wodgina. The stanniferous dykes of this type are, without doubt, the source of much of the alluvial tin in this district, and they are, therefore, well worthy of notice from prospectors, in the hope of some of them being found large enough and rich enough to be worked as lodes. Seeing how widely the tin ore is scattered it seems probable that the stanniferous veins are very numerous, and among them there should be good hope of a payable discovery.

West of Cooglegong, on the fall of the Shaw River, several men were working near the "Shaw Patch" well, getting tin ore from the shallow ground, and also from somewhat deeper leads.

It has been proposed to work the beds of the Shaw River and Cooglegong Creek for tin ore, and seeing that these streams are the main waterways of the district, taking the drainage from a huge extent of stanniferous country, and being the main channels into

which all material denuded from the surface by the action of rain and running water must have been swept for ages, to be there concentrated by a long-continued process of natural ground-slucing, there seems every reason to believe that they must contain a large amount of tin. The beds are, however, very wide, and filled to a considerable depth with light gravel and sand which would have to be removed to get at any payable stanniferous "wash," so that their working is a proposition requiring handling on a fairly large scale to have any hope of success. Ordinarily there is no water in these streams, except in pools here and there along them, but during the heavy rains to which the district is subject, they may become wide and deep rivers which would sweep away and overwhelm any machinery and sluicing appliances that could not be very quickly removed.

I was not able to get any information of value as to the prospects of tin ore obtainable in the beds of these streams. Holes were said to have been sunk in the Cooglegong bed, but were not completed on account of the influx of water being too great for manual work. I am very doubtful, however, if any determined effort has ever yet been made to search for tin in these river beds, as it should not be a very difficult matter to sink deep enough to be able to dredge up satisfactory samples of the bottom "wash" even if the water is pretty heavy. A good deal of testing could be done quickly by boring.

Should it be found on trial that there is enough tin in the river beds to be worth putting machinery upon them, the deposits could be readily worked by dredging, provided also, that it was found that there was a sufficient supply of water for this purpose obtainable from the gravels. If a large water supply is not so obtainable very readily, the problem of devising a profitable method of working may be a difficult one. The whole proposition requires very careful preliminary investigation.

The following table shows the recorded production of Black Tin ore from the Cooglegong and Old Shaw Tinfields to end of April, 1907 :—

	1906.		1907 (to 30th April).		Total to 30th April, 1907.	
	Stream Tin.	Value.	Stream Tin.	Value.	Stream Tin.	Value.
	tons.	£	tons.	£	tons.	£
Cooglegong ...	147·09	16,284	40·60	4,462	948 04	72,925
Old Shaw ...	...	...	...	...	220·79	14,949
Total ...	147·09	£16,284	40·60	£4,462	1,168·83	£87,874



West from Cooglegong, across the Shaw River, the country changes again to rough hills of greenstone schists, etc., of the Warrawoona series. An alluvial gold "rush," known as the "Keep-it-Dark," was in this vicinity, and a little further north are the Asbestos discoveries lately acquired by the Pilbara Asbestos Coy. The granite country, according to the geological map, extends some 15 miles north from Cooglegong down the Shaw River, but the boundary between it and the greenstone schists then turns back again to the south-east, being crossed on the road from Cooglegong to Marble Bar near the Black Range Well.

#### NORTH SHAW.

From Cooglegong to North Shaw the road lies over granite plains with frequent rocky island-like hills of granite standing up from them. Near North Shaw dioritic schists are encountered, which form the country enclosing the auriferous and cupriferous reefs of this centre. The old North Shaw township is entirely removed, and the old mines have all been abandoned. The Government Geologist has quoted Mr. Becher's report on these at the time they were working, in Geological Survey Bulletin No. 23. The principal mines were the Eldorado (G.M.L. 88), Eldorado West (G.M.L. 223), Bertha (G.M.L. 431), Auraria (G.M.L. 394), and Leviathan (G.M.L.s 211-212). On these there are fairly strong east and west reefs on which some work has been done to depths not more than 60 feet. The stone contained a good deal of sulphides of iron, copper, and lead, and some silver ores, and some of it was of very good value in gold. Mr. Becher's report mentions that on the Nil Desperandum lease (G.M.L. 378) "a small very highly mineralised (copper) reef of about eight inches to 18 inches outcrops flatly around the base of low hill; probable course east and west and underlay north," and that samples gave him good prospects of gold. This seems likely to be the same ground that has lately been taken up by Messrs. Bonner and Royer as a prospecting area for copper and gold. These prospectors have opened up several copper-bearing veins, on one of which an old shallow shaft had been sunk, which is probably one of the old Nil Desperandum workings. There is an east and west vein of quartz and copper ores in this shaft corresponding to Mr. Becher's above description. About 20 feet north of this line, however, the present prospectors have opened up a parallel copper lode, also dipping flatly northward, up to two to three feet wide, with some very good "liver" or "tile" ore, oxide of copper, and blue and green carbonates of copper. The ore vein is often 10 or 12 inches wide, the lode carrying a "horse" of kaolin in the middle. A heap of several tons of very good export ore had been collected from the workings, which are still merely shallow open cuts on the outcrop, and this was being bagged for shipment at the time of our visit. These two lodes have been traced some distance up the hill to the eastward, showing fair copper ore that seems well worth opening up further, and to the south of them is another vein running

north 10 degrees west, which contains some nice oxide and carbonate ore with quartz, and seems a fairly strong lode. There are several veins showing copper ores over an area of two or three acres in this vicinity, requiring more prospecting to show which of them are of value. Near the top of the hill, to the east of the workings, there is a large "formation" of much contorted schist quartz and dolomite, which shows a few stains of copper carbonate, and has probably some close connection with the lodes which seem to strike into it. Very little work has been done yet to open these copper lodes, but from the plentiful occurrence of green copper stainings and the good value of the ore already obtained, they seem very well worth testing more thoroughly.

On the day of our visit another lode was found some distance from the above with good copper ore in the outcrop. We had not time to visit Watson's P.A., about two miles further west, but saw some very good brown oxide ore ("tile" or "liver" ore) from it, some of which showed gold freely through it. The vein is said to be three to 15 inches thick.

A sample of the "liver ore" from Watson's mine given to me at Cooglegong was analysed by the Government Mineralogist, showing :—

		per cent.
No. 3366.	Moisture	0.50
	Silica $\text{SiO}_2$	16.66
	Alumina $\text{Al}_2\text{O}_3$	trace
	Lime $\text{CaO}$	trace
	Iron $\text{Fe}$	9.36
	Copper $\text{Cu}$	40.95
	Sulphur $\text{S}$	8.79
	Oxygen $\text{O}$ , Carbonic Acid $\text{CO}_2$ , etc.	23.74
		<hr/> 100.00 <hr/>

No Nickel, Zinc, or Lead.

On dry ore the assay is—

Copper	41.15 per cent.
Silver	29ozs. 45dwts. 6grs. per ton
Gold	0ozs. 0dwts. 13grs. per ton

Messrs. Maher and Miles, of Marble Bar, were good enough to give me a copy of the account sales of parcels sold from Bonnor and Royer's P.A. to the Fremantle Smelting Works, which give interesting figures, not only of the value of the ore, but also costs of marketing and smelting it.

<i>No. 1 Shipment, 6th February, 1907.</i>		£ s. d.	£ s. d.	£ s. d.
cwts. qrs. lbs.				
42 bags Copper Ore = 19 3 23				
Assay 21·75 = 18·75 = 18·71 units ...	0 19 8	18 10 5		
— 3				
„ Gold 17 ... ..	4 0 0	0 12 10		
£ s. d.			19 3 3	
Less smelting charges ... 2 2 0				
„ freight and wharfage 1 4 0				
„ cartage, harbour charges, insurance, and commission ... 7 14 0				
	...	..	11 0 0	
			8 3 3	
tons. cwts. qrs. lbs.				
42 bags Copper Ore = 1 0 3 4				
Assay Copper 25·00 = 22 per cent. ...	0 19 8	22 12 8		
— 3				
„ Gold ... 13 „	4 0 0	0 10 3		
£ s. d.		23 2 11		
Less smelting charges ... 2 2 0				
„ freight and haulage 1 8 10				
„ cartage, harbour charges, insurance, and commission ... 7 14 0				
	...	11 4 10		
			11 18 1	
<i>No. 2 Consignment, 25th March, 1907.</i>				
tons. cwts. qrs. lbs.				
153 bags Copper Ore = 3 14 0 0				
Assay 32·6				
3·0 = 29·6 per cent.	0 19 9	108 19 5		
£ s. d.				
Less smelting charges ... 7 8 0				
„ freight, haulage, etc. 5 1 6				
„ cartage, harbour charges, insurance, and commission ... 28 9 10				
	...	40 19 4		
			68 0 1	
<i>No. 3 Consignment, 5th April, 1907.</i>				
tons. cwts. qrs. lbs.				
91 bags Copper Ore = 2 0 2 25				
Assay 23·85				
3·00 = 20·85 ... ..	0 18 0	38 4 1		
£ s. d.				
Less smelting charges ... 4 1 5				
„ freight, etc. ... 2 3 3				
„ cartage, harbour charges, insurance, etc. ... 16 1 10				
	...	22 6 6		
			15 17 7	
Net proceeds of 7 tons. 15cwts. 1qr. 24lbs.	...	...	103 19 0	



Summarising these we get—

	Costs.	Gross Value.	Per Ton.	
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
7 tons 15cwt. 1qr. 24lbs. net of ore = 7.7732 tons ...				
Smelting charges ...		189 9 8	...	24 7 6
Steamer, freight, wharfage, and haulage at Fremantle	15 13 5	...	2 0 4	
Cartage, handling at ship- ping port, insurance, and commission ...	9 17 7	...	1 5 5	
	59 19 8	85 10 8	7 14 4	11 0 1
Total, net £103. 19s. 0d. = £13 7 5				

In the above method of reckoning the deduction of three units of copper from the assay value is made before computing the gross value. The average price realised was 19s. 3d. per unit, so that the full assay value was £2 17s. 9d. more than the above gross value, or £27 5s. 3d. a ton, and the smelting charges were also in reality greater by the same amount, thus coming to £4 18s. 1d. per ton, and making total costs, as reckoned against full assay value £13 17s. 10d. The costs of mining and hand-picking the ore, of bags, and filling and sewing bags, are not included in these figures, but are chargeable against the net return. The cartage to Port Hedland was done at a very low figure for the district, viz., £6 a ton, but this favourable rate could not be always obtained. At present prices of copper the ore would have to have an assay value of close on 17 per cent. to pay expenses of mining, bagging, export, and smelting. It is clear, therefore, that no extensive copper mining can be expected until this excessive figure can be greatly reduced. The best hope is that the mines will prove themselves able to supply a small smelting furnace on the spot, but until they are much more opened up than is yet done this cannot be thought of. If other copper discoveries are made in the field, however, the case may at any time assume a different aspect.

The official record of gold returns reported to the Mines Department to end of April, 1907, from North Shaw is:—

Alluvial ...	7.53	ozs. fine.
Dolled and Specimens ...	567.06	„
Ore treated, 351.45 tons for ...	674.72	„
Total 351.45	1,249.31	„

#### NORTH SHAW TO MARBLE BAR.

The route followed ran eastward to the Black Range Well, there joining the road from Cooglegong to Marble Bar. Very soon after leaving the old Eldorado mines at North Shaw the road passes on to granite country, which continues to Black Range Well. Not far from North Shaw, a big diabase dyke

is crossed, similar to that forming the Black Range. North of the Black Range Well we come first upon a coarse conglomerate of granite and greenstone boulders, which is very probably one of the basal beds of the Nullagine series. The country is rugged and hilly from here onwards nearly to Marble Bar, and seems to be mostly composed of flat-lying slates, conglomerates, and lavas of the Nullagine series. This interesting stretch of country is described more fully in Geological Survey Bulletin No. 23, under the heading of the Just-in-Time mining centre. This locality was not visited by me, no work being in progress there. The Government Geologist in his Bulletin has drawn attention to the auriferous contents of some of the basal conglomerates of the Nullagine series at this place, and has described three of the mines in which some work was done on these conglomerates. The recorded yield is small, only 60 tons having been returned as crushed for a yield of 47.30ozs. of gold (unrefined). Mr. Maitland remarks "The occurrence of an auriferous conglomerate, in the same stratigraphical series, at least 50 miles distant from Nullagine where identical geological conditions prevail, would seem to encourage efforts in the direction of carefully prospecting other portions of the basal members of the series, which occupy such an extensive area in the North-west district."

#### MARBLE BAR DISTRICT.

The Geological Survey report and map (Geological Survey Bulletin No. 20, pp. 105-120) of the Marble Bar district show it to possess a rather complicated geological structure, no less than ten separate sorts of rock having been distinguished and mapped. The main country on the west side of the field is dioritic and metamorphic schists, and on the east side granite, but both are penetrated by numerous dykes of porphyry, diabase, and gabbro, and in parts of the district overlaid by lavas, agglomerates, and other strata belonging to the Nullagine formation. The celebrated "Marble Bar," on the Coongan River, is a huge outcrop of the jasperoid quartzite referred to previously in the geological sketch, traversing the schist. It is very regularly laminated, and often strongly coloured in shades of pink, red, and blue-black shades. Much of it is highly suitable for ornamental lapidary's work. Nearly along the contact of the granite and the schist, and running nearly north and south for about three miles in length, there lies an interrupted belt of sheared greenstone very similar to the schistose diorites and amphibolites of the Eastern Goldfields, and along this belt occur a succession of quartz reefs, on which a good deal of mining work has been done, and which have yielded a very considerable amount of gold. The reefs have various directions of strike, and differ greatly in the amount of their underlay. The surface of the country is hilly—though none of the hills are very high—and is traversed by numerous ridges and gullies. In many of the gullies there has been a lot of working for alluvial gold, but

reliable returns of the amount of this which was won are not obtainable. The ground worked was very shallow and stony, but according to local report gave very payable returns while it lasted.

At the time of our visit the mines at Marble Bar were practically all idle with the exception of the Coongan Star and Franklin, on which a little work was being done. The description given in Geological Survey Bulletin No. 20 still holds good for the mines and renders it unnecessary for me to again give particulars of the work done in each, but a few notes may be given upon what is now visible.

To the north of Marble Bar the road from Port Hedland passes the old *White Angel* mine (G.M.Ls. 649, 210), the shaft of which now serves as a settler's homestead well: it has not been worked for many years and I obtained no information about its reef or the returns from it, if any. Further south, within a mile of Marble Bar township, the old *Band of Hope* (G.M.L. 533) and *Ironclad* (G.M.Ls. 2, 4, 482, 483) mines were all on a strong north and south reef running through several leases and showing frequently a big outcrop. On the *Ironclad* lease (G.M.L. 2) the Geological Survey Report notes five well-defined reefs altogether, in the sheared greenstone country. A considerable amount of work has been done along the outcrops of the reefs, and large amounts of quartz have been left uncrushed. I was informed that prospects equal to 15 to 18 dwts. per ton could be obtained from some of this stone by panning tests, but cannot believe that much of this average grade could have been left untouched where it was so cheaply obtainable. The probability is that the owners took out the richer stone wherever they could get it and left standing only that which they did not think would pay them, and it is quite likely that parts of the poorer stone will occasionally prospect well. The Government Geologist's report gives the returns from the *Ironclad* reef as 1,441.57 ozs. of gold from 2,040.50 tons crushed, or an average of 14 dwts. per ton. When mining facilities in the district have been so improved as to permit the profitable working of low grade stone it is probable that much of the quartz left untouched formerly will be found worth crushing. The nature of the workings gave me the impression that the miners had followed richer ore occurring irregularly in the reef rather than that they had worked out definite ore-shoots.

The main reef is three to six feet wide and underlies somewhat flatly to the westward; the quartz is in short blocks and detached bodies, as if the reef had been much fractured and heaved. Seeing that the reefs are older than the Nullagine series of strata overlying the schist country, and that there have been movements of the earth's crust sufficient to considerably bend and crumple these younger strata, it is only to be expected that the reefs might be a good deal broken and twisted by the same movements, and this may be the explanation of many of their irregularities.



I was informed that the old vertical shaft of the Ironclad mine was about 125 feet deep, and that there was at one time a battery of ten or fifteen heads of stamps on the ground.

South of the Ironclad is the old *Bohemia* mine (G.M.L. 6) on which a lot of shallow work has been done on the outcrop of a very flat-lying reef. There is a large amount of quartz here readily obtainable, but presumably too poor to be worth crushing at the time the mines were working. There are also workings some three or four hundred feet further east on a flat body of stone which may perhaps belong to the same reef. The stone contains much oxide of iron and some of it shows a little copper pyrites.

In the old *General* mine (G.M.L. 8,485) still further south, the reef runs about north 55 degrees west with dip to south-west, and cuts through a dyke of diabase. The main shaft is said to have been about 130 feet deep, and the first 250 tons crushed are stated to have returned  $4\frac{1}{2}$  ounces of gold per ton.

The *Homeward Bound* mine (G.M.Ls. 472, 579, 638) had a lot of workings on the side of a hill on which a flat reef crops out dipping almost parallel to the slope of the hill. Near the foot of the slope a shaft about 80 feet deep (water level) is said to have cut the reef four feet wide and worth about 18 dwts. per ton. As in the above mentioned reefs there is a large amount of quartz exposed in the various workings which has evidently been considered not worth crushing. The stone contains a little copper pyrites. The Homeward Bound reef is recorded in Geological Survey Bulletin No. 20 to have crushed 1,728.50 tons of quartz for 2,420.30 ozs. of gold.

*The True Blue* (G.M.Ls. 85, 187).—Workings were on a big reef running W.N.W. and E.S.E. There is a large amount of quartz in the shallow surface workings, some of it stained with carbonate of copper. 183.25 tons are recorded to have returned 310.02 ounces of gold.

On the *Coongan Star* (G.M.Ls. 92, 623) two men have been working lately, getting good stone. The reef is rather a flat one, and several small shafts have been sunk to cut it. The stone often shows stains of copper carbonate. I have been unable to find any record of later crushings than those given in the Government Geologist's table, where the return from 331.25 tons treated is given as 598.95ozs.

The *Augusta* mine (G.M.L. 615) has been pretty extensively worked, the main shaft being sunk about 400 feet on the underlay of a very flat reef, the bottom level of which is about 70 feet below the surface. The reef is about 3 feet wide, but varies from 1 to 7 feet. The stone carries a good deal of copper, enough to interfere with cyanide treatment of the battery tailings. Several shafts have been sunk on the *Stray Shot* section of the ground, on which

there is a 5-head battery, the only one at present available in the district. The Government Geologist's report gives the record of the Augusta mine as 5,619.40 tons crushed for 14,057.73ozs. of gold, but I was informed when going over the ground that locally it was believed that about 16,000 tons in all had been crushed from it, much of which was never recorded. Since the end of 1904, to which date the Government Geologist's table is made up, 212.20 tons more have been recorded as crushed for a yield of 378.18 ounces of fine gold.

The reefs of the above auriferous belt are strong, well-defined bodies of quartz, and undoubtedly fissure veins. They have the reputation of having contained the payable ore in short shoots but from the appearance of the workings it seemed to me that the "eyes had been picked out" by taking only the richest ore, and that this could not properly be said to be in shoots at all. According to the information I received from men who knew the mines when they were worked, there is a large amount of low-grade ore in them in the shallow ground already opened up, and every prospect that if the reefs were systematically opened up below the water level they could be profitably worked once there is railway communication from the coast to Marble Bar. The record of the reefs is really excellent as regards value of the ore crushed, and it seemed to me that it could not be said that many of them had ever had a fair trial. These reefs seem very well worth attention from investors. Careful and systematic sampling and assaying of the quartz still in sight would give valuable information as to the prospects of being able to work the reefs in bulk as low-grade concerns.

The *Franklin* (G.M.Ls. 641, 655) mine is situated about three miles south of Marble Bar in laminated dioritic schist country forming rough stony ridges. There are two nearly parallel reefs lying close to one another, the distance between them being 14ft. 6in. at the shaft workings. They run nearly N. and S. and underlay somewhat flatly to the west. The reefs are from 2 to 6 feet thick, and would average about 3 feet. They join together both to the north and south of the shaft workings and perhaps should be regarded as one reef with a somewhat long "horse" in it. It is clearly a fissure lode, though lying nearly in the lamination of the schist, as it cuts through this in places, shows occasional enclosures of "country," and has good well smoothed walls. Not much work has been done as yet, but two leases are still held and worked. The recorded output to the end of April, 1907, is 189.01 tons crushed for 316.93oz. fine gold. The outcrop is easily traced a considerable distance both north and south from the workings, and is said to carry gold for a fairly long way. It has been sunk upon by a shallow shaft, but as the reef rapidly rises into a hill to the south it could be readily worked by a short crosscut tunnel from the gully which crosses the reef north of the shaft and driving south therefrom on the course of

the lode. The reef is a strong and distinct body of quartz and seems well worth prospecting thoroughly. The stone shows a little copper pyrites at times, and in some of it gold could be seen readily.

The officially recorded output of the Marble Bar district to end of April, 1907, is 9,202.09 tons crushed for 15,517.19oz. fine gold, 170.91oz. fine gold from dollying, and 8.94oz. from alluvial, making a total of 15,697.04 fine ounces. This, however, does not include a large amount of alluvial gold not segregated to the centre where it was produced in the returns from the Goldfield generally, which for the same period gave a total of 6,014.06 fine ounces, and a probably still larger amount which was never reported at all. The Government Geologist's Bulletin No. 20 gives the following table of production of the Marble Bar Reefs to the end of 1904, which, though the gold has not been reduced to fine ounces and so is not absolutely comparable with the statistical return, shows at a glance that he was able to obtain records of both more stone crushed and more gold therefrom than is shown in the latter.

*Synoptical Table showing the Yield of the Marble Bar Reefs up to the end of 1904.*

Name of Reef	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Augusta ... ..	5,619.40	14,057.73	2.50
Augusta No. 1 South ... ..	66.00	149.60	2.26
Coongan Star ... ..	331.25	598.95	1.80
Excelsior ... ..	Included under Augusta.		
General ... ..	Included under Homeward Bound		
Homeward Bound ... ..	1,728.50	2,420.30	1.40
Ironclad ... ..	2,040.50	1,441.57	.70
Ironclad South ... ..	61.00	24.00	.39
Iron Duke ... ..	40.00	25.70	.64
Keep-it-Dark ... ..	32.50	73.65	2.26
Marble Bar ... ..	11.00	15.70	1.42
Pillendinnie ... ..	1.00	342.00	342.00
Rejected ... ..	Included under Homeward Bound		
Robert Bruce ... ..	112.00	116.92	1.04
Shamrock ... ..	60.25	142.80	2.37
Stray Shot ... ..	Included under Augusta.		
Sundry Claims ... ..	443.80	4,532.29	10.21
Trafalgar ... ..	30.00	90.00	3.00
True Blue ... ..	183.25	310.02	1.69
Total ... ..	10,760.45	24,341.23	2.26

This is an excellent average return, spread over a large number of mines, none of which have been opened up extensively, or to any considerable depth. The reefs show large and strong bodies of quartz and have every indication of being persistent in depth, and



it seems to me that they have been so unsystematically worked that there is no sound foundation for the commonly held belief that the gold is in very short shoots. It is doubtless very patchy in its occurrence, but there are very good grounds for thinking that several of these mines could be reopened with profit when working conditions are improved.

The auriferous dioritic country runs northward from Marble Bar for about 20 miles to Doolena Gorge, and is then cut off by the great granite coastal plain. A narrow strip of it, however, is shown by the Geological map to run eastward from Doolena Gorge about 40 miles, to past Bamboo Creek. This country is also seen south of Marble Bar for about 10 miles, then turns south-east through Warrawoona to Yandicoogina, and thence northward again towards Bamboo Creek. It seems to form quite a narrow strip of country, except on the western side, where it probably is connected with a larger greenstone area, part of which is concealed beneath the overlying strata of the Nullagine series. It is noteworthy that at Marble Bar, Warrawoona, and Yandicoogina the rough hilly ranges in which the greenstone schists outcrop follow approximately the strike of these, which is roughly parallel with their contact with the granite country, strongly suggesting a close connection between the intrusion of the granite and the tilting on edge of the metamorphic and dioritic schists of the Warrawoona series. I am not yet aware if the same feature is seen in the strip of this country running east of Bamboo Creek. It is so at Yandicoogina, and at Lennon's Find, some miles further north.

These strips of the greenstone country nearly surround a large area of granite, part of which has been proved tin-bearing and all of which seems to deserve special attention from prospectors for tin.

#### MOOLYELLA DISTRICT.

The Moolyella tinfield lies towards the west side of the granite area just mentioned, about 10 miles east of Marble Bar. The workings are mostly alluvial, on leads running from a patch of low granite hills rising out of the general granitic plain. The principal leads run northward, but the tin has also been found more or less all round the hills, and the discoveries seem to be extending. Some of the tin ore is found in very shallow ground, almost on the outcropping granite, and is doubtless derived from small veins in this. In some of the flats where the surface alluvial layer is deeper there are two portions which have been workable, the bottom "wash" in well-defined "leads" and the top foot or so of the drift, the latter no doubt representing the results of concentration *in situ* of the tin ore which was at one time distributed through a much larger bulk of overlying drift. The defined "leads" represent the concentrations in watercourses at a time when these were cutting their way down into the granite bedrock before some change in conditions caused the valleys to be refilled with drift.

The Moolyella Field is described in *Geological Surrey Bulletin No. 15*, with a map which shows the heads of what were the three principal "leads" at the time of the Government Geologist's visit in 1903. It also shows a series of strong quartz reefs and several pegmatite dykes running roughly north and south through the country at the head of the leads. Since then the field has developed considerably, particularly in Berne's Flat and down the Moolyella Creek towards its junction with Brockman's Creek, to the west and north-west of the ground shown in the geological map. Berne's Flat was first worked by dryblowers, who treated the very shallow soil in the watercourses on the granite bedrock and the superficial tin-bearing layer on the flat. They did not, however, go to bedrock in the flat, and so missed the deep lead. This was discovered by McDonald Bros. and Party, who took up nine claims, 200 yards by 100 yards, giving them a length along the lead of 1,800 yards by 100 yards in all. The ground has been found to average about 15 feet in depth, with two feet of payable "wash" on the bottom, the width of the bed being about 30 feet on the average, though often narrower, and sometimes up to 100 feet. The wash is somewhat clayey but puddles fairly freely. It is mostly light material but contains numerous sub-angular stones of quartz, felspar, and granitic vein stuff. The tin oxide is fairly coarse and not very much water worn, but gets finer in grain lower down the lead. The "wash" is raised to surface from numerous windlass shafts and carried to a puddler worked by a horse. This puts through about 20 loads per day of eight hours. The tin got by washing out the puddler is hand-jigged and dressed till clean, when it assays about 72 per cent. metallic tin, and is bagged for shipment, going now to Singapore to be smelted. At the time of our visit McDonald and Party had obtained about 470 tons of black tin from their ground, valued by local buyers at £103 a ton on the ground. Carting to the coast costs £6 a ton, and total expenses to the Singapore Smelting Works were given to me as £13 10s. a ton. The mining and puddling costs were about 25s. per cubic yard of dirt, or equal to the value of 27lbs. of black tin, which is therefore about the minimum yield per yard that is payable. The actual yield has been much higher, this having been a very profitable claim. It is, however, nearly worked out now.

North of McDonald's ground comes that of Prouten and Party, who have two men's ground, or 400 yards by 100 yards. They have the lead at about the same depth as McDonald, and had got 79 tons of tin up to the time of our visit. Cheriton's, Markell's, Collingwood's, and Moore's claims then succeed one another following the lead northward. Two of these parties were working with hand puddlers and cradles. The wash and tin both become lighter towards the lower end of the lead. It seems likely enough that further extensions of the lead to the northward will yet be worked.

In the Huntsman's Creek very little work has been done lately, but there seems some reason for trying to trace it down into the deep ground also.

In the Moolyella Creek the workings have now gone into the deeper ground in the flats, the upper shallow portions being worked out. The first claim examined was that of another McDonald and Party who were working ground 12 feet deep by open paddocking. The wash was about four feet thick, containing rather fine-grained tin ore, but the bottom of the lead had not been laid bare. The wash was considered highly payable.

Next to this claim comes 10 men's ground held by McDonald, Muir, and Party, who have the lead at a depth of 24 feet. The wash is about two feet thick and fully 100 feet wide ; tin ore rather fine grained. It is considered payable, but had not been washed at the time of our visit, being stacked for treatment.

Below this comes McLaren and Party's claim of 1,000yds. by 100yds. Several shafts have been sunk 25 feet to the lead, and connected by a drive along its course 200 feet long, with frequent crosscuts which show the lead to be 20 to 40 feet wide. Mr. McLaren proposes to do as much of his sluicing as possible underground, in boxes placed in the main level, stacking the coarser tailings back in the worked out ground and pumping the sludge to surface, and was erecting machinery for this purpose at the time of our visit. The ground was very well and systematically opened up for working, and Mr. McLaren estimated that 20lbs. of tin to the ton of wash-dirt would pay expenses. A fair amount of rather fine tin ore could be seen in the wash, which was considered to be payable. This claim is well out in the flat country near Brockman's Creek. A rather deep water shaft had been sunk near the point where the lead enters the claim, but I understand that the supply of water has not proved so large as was hoped for.

Below McLaren's claim a sluicing and dredging area has been applied for in Brockman's Creek, but bores have shown the ground in the creek to be shallower than the bottom of the lead in McLaren's claim, and there is therefore a likelihood that the old deep lead system had an outlet which is buried under the flat and does not correspond with the existing creek in position. The north side of Brockman's Creek at this point shows the granite bedrock cropping out strongly, so the deep old channel must presumably lie between it and the lowest workings on Berne's flat and Moolyella Creek leads. Some lines of bores or prospecting shafts across the flats would soon show if such a deep lead exists. There is much probability of the shallow leads which have been worked being found to



unite with one another into a main lead, and the amount of tin already obtained justifies prospecting for this in the belief that it also will contain workable deposits.

At the head of the Moolyella Creek all the small watercourses on the slopes of the granite hill have been worked for tin ore right up to the hilltop, the tin ore obtained being very crystalline and often having veinstuff adhering to it. Numerous veins are seen traversing the granite of albite and quartz with mica and green talc or hydromica. The veins lie very flat as a rule and are not big enough or regular enough to be worked as tin lodes, though some of them are rich enough in tin ore to be well worth working if they were a little larger. Probably in course of time some will be found big enough to work. The veins are not numerous enough to form a "stockwork," but are sufficiently plentiful to have yielded a large amount of ore to the alluvial deposits by their disintegration under weathering agencies.

On the opposite side of the hill near the head of Berne's flat there are several more veins of the same sort, one of which is known as Eley's lode. One of the veins is at times as much as 3 feet wide, mostly felspar and quartz with coarse crystalline tin oxide—one vertical vein about 10 inches wide was worked to a depth of 5 or 6 feet, the ore being dollied. The veins are irregular in size and occurrence and do not appear to be true fissure lodes, but rather "segregation veins," and are not very promising from a mining point of view. They are important more as showing the nature of the occurrence of the tin ore in the bedrock than as workable propositions themselves. It is very possible, however, that larger and better ones, though of this type, may prove well worth opening as lode mines. The veinstuff is quite similar to Geological Museum specimen No. 5397, of which an analysis is given on page 12 of *Geological Survey Bulletin* No. 15.

About two miles south from the "Mud Springs" Government Well there is a big outcrop of very fine lode tin ore in a large pegmatitic vein, known as Atkins' lode, of quartz, felspar (orthoclase and albite) and greenish mica, running west-north-west and east-south-east. The lode is up to 12 feet wide, and some parts of the outcrop are nearly all quartz, while others are mostly felspar. Where the tin ore is found it is mostly in a matrix of greisen (quartz and mica), but some of the felspar also carries cassiterite. A shallow cut had been made into the lode at this point, several holes having been drilled and fired, but the place was not well cleared out so that a good view could be obtained. Beautiful specimens of tin ore were easily obtainable, the stuff being very rich, but much more work is required before it can be seen what is the

extent of the patch of ore. It is very well worth opening up more thoroughly and there seems a good chance that a payable shoot of ore exists of good size for working. A sample of the good ore analysed in the Geological Survey Laboratory yielded 13.31 per cent. of metallic tin, and some of the best ore is a good deal richer than this. The vein, however, is rather a pegmatite or segregation vein than a true lode.

A short distance to the north of Atkins' lode I noticed another large pegmatite vein showing a little tin ore, on which no work had been done. Still further north close to Mallet's fence there are some well-defined pegmatitic veins of quartz, pinkish orthoclase felspar and mica carrying a large amount of magnetite, which is easily mistaken for tin ore. A good deal of this magnetite is seen lying about the surface of the ground in the vicinity of these veins.

Another lode, known as Martin's, somewhat similar to Atkins' has lately been found near the head of Berne's flat to the south-east from the township there. It seems to be about 4 feet thick, but is not well exposed by the little work as yet done on it, and contains some fair tin ore. Its course seems to be about north-north-east and south-south-west. Another vein lying rather flatly with some very good tin ore in it has been found by dry-blowers a short distance east of this find. This ore is in a matrix of greisen quite like that of the ore shoot in Atkins' lode, and the discovery seems well worth prospecting further.

Atkins' and Martin's "lodes" may prove to be workable reef propositions, and their discovery gives hope that lode mining for tin may become established in the Moolyella district. Unfortunately at present there are no means of crushing the stone to extract the tin oxide. Crushing and dressing machinery will be required for this before the lodes can be profitably worked.

The yield of tin ore from the Moolyella field is officially recorded as—

To the end of 1906	...	Stream tin	1,705.19 tons	valued at	£138,762
"	"	April, 1907	...	"	"
			211.90	"	23,622
Total			1,917.09	"	£162,384

There were said to be about 500 people on the Moolyella field at the time of our visit; and though the shallow ground at the head of the older leads has been worked out pretty well there is still a lot of work to be done in the deeper ground, and the field should therefore maintain an output of alluvial tin ore for two or three

years longer even if no new leads are found. The discovery of Atkins' and Martin's lodes, some distance from the known leads, however, suggests that the field must be a good deal more extensive than the present workings, and further alluvial finds are to be expected as prospecting goes on. There is also a certain amount of prospect of lode mining becoming an established industry.

#### WARRAWOONA.

The belt of dioritic and metamorphic schist country seen at Marble Bar is found continuing south and south-east from there through Wyman's Well (or Salgash) to Warrawoona, forming rugged steep serrated ridges. This district has been very fully described, with illustrative maps, by the Government Geologist in his *Bulletin* No. 20, to which reference should be made. Some of the strata are of sedimentary origin, comprising highly metamorphic quartzites, conglomerates and schists, while others are igneous rocks, usually rendered highly schistose by the pressure and shearing stresses to which they have been subjected. The granite country on the northern side of the hills has apparently participated to some extent in these compressive and shearing stresses as it is somewhat foliated close to its junction with the schists parallel to their lamination.

The only one of the Warrawoona mines which was visited by myself was the Klondyke Queen (G.M.L. 627), formerly known as the "Klondyke," under which latter name it is described in the Government Geologist's report. The workings are above and below a tunnel driven north-westerly on the course of the lode, which consists of a series of somewhat lenticular bodies of quartz enclosed in the lamination of the schist, but nevertheless in my opinion of the fissure-vein mode of origin. There seem to be two or three closely parallel veins lying more or less *en echelon* along the general line of the lode. Above the tunnel the reef has been stoped out for some 90 feet or so in height, and it has also been worked by winzes down to water level about 80 feet below the tunnel. The reef has been worked for over 300 feet in length. This has been a very rich reef, the returns quoted by the Government Geologist showing to end of 1904, 731.75 tons crushed for 4,784.40 ounces of gold, or at the rate of 6.53 ounces per ton. At the time of my visit a little work was again being done on it. From what I could see of the reef it seemed likely to be very persistent in depth, and I am of opinion that the values will also be found to continue downwards satisfactorily. It is not usually a large reef, but of quite workable size, and it is a great pity that it has not been opened up in depth.

The Government Geologist's map shows a long belt of reefs running north-westerly for a distance of six miles and width of 20



chains, and his descriptions show that many of the reefs are of fair size and that they have given very good crushing returns. At the time of our visit there were only 16 men working on the field, but some of them were on very good gold, and there is no doubt that in a more favourably situated part of the State for working conditions this field would be supporting a large number of men. The following table from the Government Geologist's report shows the output from the various reefs to end of 1904:—

*Synoptical Table showing the yield of the Warrawoona Reefs up to the end of 1904.*

Name of Reef.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Admiral Dewey ... ..	8·45	4·55	·53
Bow Bells ... ..	483·70	855·69	1·76
Bow Bells Block No. 1 ... ..	12·00	10·50	·87
Britannia ... ..	19·00	28·70	1·51
Brought to Light ... ..	8·75	7·96	·90
Carnoustie ... ..	45·40	178·11	3·92
Chance ... ..	4·00	8·35	2·08
Criterion ... ..	12·20	7·80	·63
Cuban ... ..	51·30	215·41	4·19
Cutty Sark ... ..	36·05	59·10	1·64
Dead Camel ... ..	18·75	63·50	3·38
Gauntlet ... ..	1,289·30	3,693·55	2·86
Gift ... ..	44·05	73·50	1·66
Golden Gate ... ..	59·45	124·50	2·09
Golden Gauntlet ... ..	3·00	4·60	1·53
Imperialist ... ..	695·75	810·58	1·16
Juneau ... ..	13·85	15·33	1·10
Klondyke ... ..	731·75	4,784·40	6·53
Klondyke Block ... ..	37·00	764·00	20·65
Klondyke Boulder... ..	1,016·16	2,450·93	2·41
Klondyke No. 1 West ... ..	43·00	189·67	4·41
Klondyke Queen ... ..	9·90	13·75	1·38
Nelson ... ..	1·25	5·29	4·23
Princept ... ..	2·15	5·00	2·32
Princess of Alaska... ..	40·00	70·61	1·76
Rangatira ... ..	8·50	5·15	·60
Reward Claim 94 ... ..	351·55	1,037·89	2·95
St. George ... ..	20·00	124·00	6·20
Tom Thumb ... ..	36·55	164·66	4·50
Treble Event ... ..	3·25	4·00	1·23
Wheel of Fortune ... ..	206·35	249·95	1·21
Sundry Claims ... ..	387·60	{ 773·29 *50·00 †433·30 }	1·99
Cyaniding ... ..	...	†6·56	...
Total ... ..	5,700·01	17,294·18	3·03

\* Alluvial. † Specimens. ‡ Nine tons of sands.

The latest official statistics to end of 1904 show 5,835.31 tons crushed, for a yield of 14,707.35 fine ounces, 335.73 fine ounces from specimens dollied, and 44.30 fine ounces from alluvial. Since the end of 1904 the following returns have been officially recorded:—

	1905.			1906.			1907, to 30th April.				Grand Total to 30th April, 1907.			
	Ore treated.		Gold therefrom.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	
Total to end of 1904	Tons.	Fine ozs.			Tons.	Fine ozs.		Tons.	Fine ozs.			Tons.	Fine ozs.	
483, 505—British Exploration of Australasia	1,253.00	744.17			160.00	358.64								
604, Klondyke Boulder	26.00	18.85			39.64	46.36								
627, Klondyke Queen					42.75	96.25								
Sundry Claims	41.45	82.53			57.94	158.48								
	1,320.45	845.55			300.33	658.73								
Total										44.30	338.15	7,456.09	16,211.63	

This is a district which can be commended to the attention of prospectors when the country becomes opened up so that mining supplies can be got at reasonable rates. At present firewood costs from £2 to £2 5s. per cord, and mining timber often up to 1s. per lineal foot. The Bow Bell's 10-head battery crushes for prospectors at 27s. 6d. a ton, without cyaniding. Unless very good stone is obtained the prospectors have found that they cannot make a living from these mines, but if conditions were improved by the construction of a railway from the coast there is every reason to be confident that Warrawoona would become a highly payable field, supporting a large population.

#### YANDICOOGINA.

The Warrawoona range of auriferous hills continues east-south-easterly to Yandicoogina. The road, however, crosses the range on to the granite plain lying north of it, and runs to Yandicoogina over the flat grassy country at the foot of it. From Marble Bar to Yandicoogina the road also passes most of the way over the same flat well-grassed country, often showing small segregation veins in the granite which encourage hopes that tin ores will be found. The granite is penetrated by occasional dykes of diabase. I did not visit Mt. Edgar, but the Geological map shows it to belong to the metamorphic and dioritic schist formation, and the similarity of its structure to that of the Wodgina District seems to warrant attention being given to it by prospectors in search of tin lodes.

The gold mines at Yandicoogina were all abandoned at the time of my visit, and I had no time to make any examination of them. They are fully described, with a geological map, in Bulletin No. 15 of the Geological Survey. From this it appears that the reefs are in a narrow belt of dioritic and metamorphic schists of the Warrawoona series running north-easterly roughly parallel to the contact with the granite, and overlaid to the east by beds of the Nullagine formation. The country is hilly, being a continuation of the range seen at Warrawoona.

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The following table is taken from the Geological Survey Bulletin 15, showing the names and recorded returns of the Yandicoogina reefs:—

*Synoptical Table showing the Yield of the Yandicoogina Reefs.*

Name of Reef.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Aunt Sally ... ..	27'00	21'00	78
Black Shepherd ... ..	611'05	1,955'29	3'20
Eastern ... ..	665'85	777'55	1'17
Granite ... ..	35'00	92'50	2'64
Harp of Frin ... ..	22'50	11'55	51
Invincible ... ..	13'40	701'00	52'31
Jupiter ... ..	113'50	586'70	5'17
Lady Adelaide ... ..	61'25	88'30	1'44
Lone Hand ... ..	16'00	23'30	1'45
Trilby ... ..	66'00	207'50	3'14
Uncle Tom ... ..	450'05	1,239'91	2'64
Zingara ... ..	8'40	6'80	80
Sundry Claims ... ..	72'75	56'10	77
Total ... ..	2,162'75	5,767'50	2'66
Tailings cyanided at Lady Adelaide Battery ... ..	(700 tons)	325'00	...
Total ... ..	2,162'75	6,092'50	2'81

With this excellent record it seems very strange that the mines should have been abandoned. The reefs seem from the Government Geologist's description to be very similar to those at Warra-woona.

*Lennon's Find.*—My visit to the Yandicoogina district was to see a new find made by Messrs. Lennon, Doherty, and party, about eight miles further north in the same range of schist hills skirting the granite, and about 10 miles south-south-east from Mt. Edgar. The hills are rugged ridges of schist running parallel with the strike of the strata, which is here about north 55 degrees east. A short distance up the hills from their foot on the north-western side a strong and well-defined lode has been found by the prospectors and traced for about two miles, lying conformably with the foliation of the schist country, but seemingly a distinct fissure vein. Its outcrop is easily traceable, sometimes forming outstanding masses of quartz and silicified country often stained with green carbonate of copper, at other times showing as oxide of iron gossan. The outcrop had been very little cut into at the time I saw it, but the actual lode itself seemed to me to be rather small, though the country on each side of it was often silicified and charged with metallic minerals. I

think, however, that it will generally be of workable width when opened up.

Going northward along the outcrop I visited first the St. Patrick lease (M.L. 137—6 acres), on which the lode is small, about 12 to 15 inches of ore being seen in a small cut on the outcrop. A sample of this ore taken for examination gave the following analysis:—

*Geological Survey Laboratory Assay No. 3373.*

Copper .. .. .	14.61 per cent.
Lead .. .. .	.39 „
Zinc .. .. .	16.33 „
Silver .. .. .	23oz. 3dwt. 12grs. per ton.
Gold .. .. .	0oz. 0dwt. 17grs. per ton.

Passing through the St. Patrick ground to the north-east the vein has hardly been scratched, and is small, apparently from six to 18 inches wide. I took a few random samples while going along it, which contained:—

*Geological Survey Laboratory Assay No. 3376.*

Copper .. .. .	17.20 per cent.
Lead .. .. .	1.66 „
Zinc .. .. .	6.93 „
Silver .. .. .	20oz. 18dwt. 13grs. per ton.
Gold .. .. .	0oz. 0dwt. 13grs. „

Another sample taken mostly from a cut on the lode near the boundary between the Prospecting Area and the St. Patrick lease gave:—

*Geological Survey Laboratory Assay No. 3375.*

Copper .. .. .	5.33 per cent.
Lead .. .. .	2.79 „
Zinc .. .. .	5.52 „
Silver .. .. .	4oz. 13dwt. 19grs. per ton.
Gold .. .. .	0oz. 0dwt. 17grs. „

Still following the lode north-easterly through the Prospectors' prospecting area (P.A. 151—18 acres) the outcrop appears poor in copper, but is much larger, forming masses of quartz up to eight feet wide. A shaft has been sunk about 15 feet, the lode being five or six feet wide in it, without the footwall being seen. It underlays about one in three to the south-east. A sample of the ore from this shaft gave on analysis:—

*Geological Survey Laboratory Assay No. 3374.*

Copper, .. .. .	6.68 per cent.
Lead .. .. .	3.85 „
Zinc .. .. .	4.45 „
Silver .. .. .	2oz. 6dwt. 20grs. per ton.
Gold .. .. .	0oz. 0dwt. 17grs. „

Another sample from a vein of baryte two feet wide in a large outcrop eight to ten feet wide near the north-east boundary of the prospecting area gave on analysis:—

*Geological Survey Laboratory Assay No. 3378.*

Copper	..	..	..	6.40	per cent.
Lead	..	..	..	5.55	„
Zinc	..	..	..	8.37	„
Silver	..	..	12oz.	1dwt. 11grs.	per ton.
Gold	..	..	0oz.	0dwt. 17grs.	„

This vein was in a mass of quartz and silicified schist much stained with green carbonate of copper.

In the *Ribbon* Lease (M.L. 143—6 acres) about a mile further north there are 12 to 24 inches of lode stuff in a much wider body of silicified schist much stained with malachite. A sample from here gave on analysis:—

*Geological Survey Laboratory Assay No. 3377.*

Copper	..	..	..	6.01	per cent.
Lead	..	..	..	.36	„
Zinc	..	..	..	.86	„
Silver	..	..	5oz.	8dwt. 4grs.	per ton.
Gold	..	..	0oz.	0dwt. 9grs.	„

I did not see the south end of the line of reef (M.L. 149—12 acres), but obtained a bag full of the ore from there which proved to contain a good deal of sulphate of lead in baryte and gave the following analysis:—

*Geological Survey Laboratory Assay No. 3379.*

Copper	..	..	..	Nil.	
Lead	..	..	..	13.89	per cent.
Zinc	..	..	..	.37	„
Silver	..	..	39oz.	14dwt. 8grs.	per ton.
Gold	..	..	0oz.	1dwt. 15grs.	„

The Government Mineralogist and Assayer in reporting these results says, "The minerals in these samples are so intimately commingled that some are difficult of exact determination. The copper appears to exist wholly as malachite with possibly a little cuprite and chrysocolla; the lead in 3379 is wholly present as the sulphate (anglesite), and probably most of that present in the other samples is in the same form though a little carbonate (cerussite) may also be present. The zinc occurs mainly if not wholly as silicate (hemimorphite). The principal gangue minerals are quartz, limonite, calcite, and barytes in varying proportions. 3379 contains about 20 per cent. anglesite, 17 per cent. quartz, and 62 per cent. barytes; calcite and limonite being almost absent. In the other six samples barytes is less abundant; calcite, limonite and quartz more so. The silica content appears to be uniformly small."



As these samples were taken from the outcrop without any attempt at picking out the more valuable ore, they are not nearly so high in metallic contents as the ore would be that would be picked out for shipment in the course of actual working. The results in copper and silver on the whole are very encouraging, though the presence of zinc is detrimental. The value of the lode cannot be gauged until some work has been done to enable it to be examined some little depth below the outcrop, and if possible below the oxidised material altogether, but present indications seem to me to warrant energetic prospecting, there being apparently very good chances of success.

The following assays of ore from this lode have also been made in the Geological Survey Laboratory.

Sample sent by Messrs. Lennon and Doherty through Inspector of Mines, April, 1907:—

*Geological Survey Laboratory Assay No. 3065.*

Copper	..	..	..	1.10	per cent.
Lead	..	..	..	2.39	„
Silver	..	..	6oz.	1dwt.	23grs. per ton.
Gold	..	..	0oz.	0dwt.	13grs. „

*Geological Survey Laboratory Assay No. 3087.*

Copper	..	..	..	12.81	per cent.
Lead	..	..	..	2.57	„
Silver	..	..	21oz.	2dwt.	12grs. per ton.
Gold	..	..	0oz.	0dwt.	13grs. „

Sample said to be from about seven tons, taken by the prospectors daily while the ore was being raised in sinking a shaft 15 feet deep, crushed, passed through sieves, and thoroughly mixed by them before forwarding it:—

*Geological Survey Laboratory Assay No. 3507.*

Copper	..	..	..	18.23	per cent.
Lead	..	..	..	0.76	„
Silver	..	..	22oz.	12dwt.	6grs. per ton.
Gold	..	..	0oz.	1dwt.	6grs. „

#### NULLAGINE DISTRICT.

The road from Warrawoona runs south-south-easterly across an extensive grassy plain of granite, on which is the Corunna Downs Station, until it strikes the hilly country again near Carbarra Well. From this to Spinaway's Well the route lies over rather rough hilly country, partly belonging to the Warrawoona series of rocks but mostly lavas and conglomerates of the Nullagine series. From Spinaway's Well to Nullagine the road traverses easier country but still somewhat hilly, and according to the geological map for the most part goes just a little to the west of the boundary between the Nullagine beds and the much older

slates, sandstones, and conglomerates of the Mosquito Creek series. A good deal of granite is, however, seen as well, and bars of Jasperoid quartzite, possibly of the Warrawoona series.

The geological structure of the Nullagine district is fully described, with maps and sections, in the Government Geologist's report in Bulletin No. 20 of the Geological Survey. His general map of the Pilbara Goldfield in Bulletin No. 23 should also be consulted, which shows the areas occupied by the various formations. The ancient sedimentary series of slates and fine conglomerates to which he has given the name of the Mosquito Creek beds is there seen to occupy a large stretch of country eastward from Nullagine to beyond the Oakover River, and northward nearly to Yandicoogina. There seems some evidence that they are younger than the Warrawoona series of rocks, but older than the great granite formation, which has intruded through them in many places. They are also penetrated by several large gabbro and diabase dykes. The strata are often inclined at fairly high angles, having been subjected to very considerable crumpling, and are overlaid unconformably, to the west of Nullagine, by the comparatively flat-lying Nullagine beds. The Mosquito Creek beds are of economic importance as they contain the auriferous reefs which have been the mainstay of the Nullagine and Mosquito Creek districts.

*Alluvial Gold.*—There has been a very considerable amount of alluvial gold obtained round Nullagine, derived from the wearing away of the auriferous reefs of the Mosquito Creek beds and the auriferous conglomerates of the Nullagine series. There are a few alluvial workers still about the field, but the output of alluvial gold is at present very small.

*Auriferous Reefs.*—These mostly lie to the east of the Nullagine townsite, where there seems to be an auriferous belt running north-easterly, comprising a group of roughly parallel quartz reefs running more or less north-east and south-west. None of these are at present being operated though a good deal of work has been done on them, and they have a very creditable record of value of stone crushed. The principal ones were the *Victory* group, about a mile south-east from Nullagine township. Several shafts have been put down on them, one being said to be 150 feet deep, but most of the others not more than 70 feet. The *Victory* reef is rather small, averaging about 18 inches in width. Parts of it were very rich, but the gold was patchy. There is said to be still a lot of stone in these mines that would yield 12 to 15 dwt. of gold per ton, but this would not pay expenses of mining, with battery charges of 35s. a ton and cartage costing 10s. a ton. The *Victory* reef has been traced for nearly a mile. Less than a mile north-east from the *Victory* and on the other side of a rough range of gabbro hills and the Kadgebut

Creek are the workings of the old *Great Eastern* mine. Here there was a shaft about 100 feet deep, now fallen in. A large reef is seen running north-easterly, the outcrop showing 10 or 12 feet in width of quartz standing out boldly as a small rocky ridge, but only about two feet of the hanging wall or eastern side seem to have been worked, so far as can be seen at surface. The country to the north-east and east from this old mine contains numerous reefs and veins, on which some work has been done, and auriferous country can be followed out towards the Mosquito Creek mines. The following table of the yield of the Nullagine quartz reefs is taken from Geological Survey Bulletin No. 20.

*Synoptical Table showing the Yield of the Nullagine Reefs up to the end of 1904.*

Name of Reef.	Ore crushed.	Gold	Rate per ton.
		therefrom.	
	tons.	ozs.	ozs.
Day Dawn	266'00	702'70	2'64
Fisher's Reward	20'00	56'60	2'83
Golden Eagle	105'95	492'95	4'65
Great Eastern	170'00	202'75	1'19
Great Eastern Extended	190'00	224'40	1'18
Promise	30'00	90'00	3'00
Sunrise No. 1.	28'00	14'00	'50
Victory	121'00	421'10	3'48
Victory East Extended	285'00	1,229'80	4'31
Victory Extended	22'00	63'00	2'86
Total	1,237'95	3,497'30	2'82

The average yield is seen to be very good, and would be even better if the gold produced by cyaniding the tailings could be added to it. 2,800 tons of tailings were cyanided in 1902-3 for 1,638.50 ounces of gold, or .58 ozs. per ton, but it is impossible to know how much of this came from the tailings from the local reef quartz crushed, how much from crushings from outside districts, and how much from conglomerate tailings. It is clear that only very rich stone was worth raising, and as this was in smallish patches that took a good deal of finding, the prospectors were only able to put out a small tonnage from each mine. It was impossible to see any of the underground workings when I visited these mines, but from the information obtained on the spot and the recorded returns, it seems probable that many of the reefs could be worked again if costs of mining and crushing were cheapened to something like those prevailing in the southern goldfields. If a much lower average grade of ore could be crushed profitably it is quite possible that the reproach of patchiness now attaching to these reefs might be removed.



*Auriferous Conglomerates.*—These are the most interesting auriferous deposits in the Nullagine district, and are worthy of special notice, not only on account of their marked similarity to the celebrated “banket” reefs of Johannesburg, South Africa, but also by reason of the very wide spread distribution of the Nullagine beds, of which they form a stratum, over the Pilbara goldfields. It has been already noted that gold has been found at the Just-in-Time district, near Marble Bar, in a similar conglomerate, and there is therefore some evidence that its occurrence in such beds of this formation is not merely a fortuitous local one, but is liable to be repeated anywhere in the areas occupied by the Nullagine beds where these are composed of the detritus of older auriferous rocks.

The conglomerates at Nullagine are fully described, with several photographs and maps, in the Government Geologist's Bulletin No. 20. No work has been done on these leases since his visit, and it is not necessary to repeat the details given by him, for which his report should be referred to. His topographical map, Plate II., taken from the plans of the Nullagine Conglomerates Gold Mines, is especially worth close study, showing the distribution and relative positions of the workings over the area on which the auriferous conglomerate has been found. The surface of the country is here a series of very rounded, often dome-like, hills, carved by erosion from a mass of nearly horizontal but somewhat curved and crumpled strata of grits and conglomerates of the Nullagine series. The workings can all be included in a quadrilateral area of about 160 acres, with base or south side extending eastward from the Grant's Hill workings about three-quarters of a mile, north side, parallel to the base one-quarter of a mile, and distance between these sides one-half mile. In this area ten or more openings have been made into the auriferous boulder bed, from which crushings have been taken, as shown in detail in the table attached to the report in Geological Survey Bulletin No. 20. From this we see that 5,167 tons altogether were crushed which returned 3,217.29 ounces of gold, equal to a general average of  $12\frac{1}{2}$  dwts. per ton. Individual crushings, however, show as high as 28 dwts. per ton and down to 2.4 dwts. per ton, the latter being the average figure for the last 777 tons crushed in 1903 from the principal workings on Grant's Hill, after which work was suspended. These workings, however, produced altogether 3,433 tons of stone, which yielded 1,780.24 ozs. of gold, or at the average rate of 10.4 dwts. per ton. The next most important workings, on the Success lease, turned out 643 tons yielding 574.65 ozs., equal to a general average of nearly 18 dwts. per ton, but in this instance also the last year's work gave poor results, 100 tons crushed in 1901 returning only 33 ozs. of gold, or 6.6 dwts. per ton.

The openings, as is easily seen from the map in Bulletin No. 20, are well scattered over the proved auriferous area, and in the

absence of good reasons to the contrary the average return from them would presumably very fairly represent the average value of the auriferous deposit in that area. It is therefore important to notice from the table of returns that good values have been obtained from crushings at several widely separated openings, and that the falling off in value of the last stuff crushed from the Success and Grant's Hill mines does not necessarily mean that the deposit as a whole has been proved to diminish in value as it is worked. It rather seems to indicate uneven distribution of values in the deposit which would be averaged if it were worked on a more extensive scale from several different openings. In the present state of the available evidence I see no strong reason for fearing that the general average return from the deposit will be greatly less than that of the 5,000 ton sample that has been actually milled.

Should this be correct, it is evident from inspection of the map of the workings that only a very small part of the auriferous bed has yet been touched and that there is a very large tonnage of ore waiting to be extracted within the quadrilateral area above referred to, not to speak of the extensions outside that area which have not yet been tested. Each foot in thickness of the deposit would give over 2,000 tons of crushing dirt per acre, and as the auriferous bed has been proved to be often four and even six feet thick, it is clear that there is a very large tonnage available, and that the successful development of these conglomerate mines is of the greatest importance not only to the district but to the State also.

My visit to these mines was a very short one, and they were not being worked, so it was impossible to form any reliable opinion from personal observation as to the values of the ore in sight. In the Grant's Hill workings, which were the only ones visited by me, the layer of conglomerate that has been worked is four to six feet thick, and lies fairly flat on the whole, but is so much curved by earth movements that it is very undulating, and rises and dips of the bed are constantly being met with which considerably hamper systematic working. The conglomerate is made up of boulders and gravel, the boulders often being as large as a man's head or even larger, but usually smaller. They are composed of hard jasper, hard conglomerate, quartz, and other hard rocks derived mostly from the underlying strata of the Mosquito Creek series. Veins of iron oxide are common, and much of the material cementing the stones together is ferruginous. In some of the deeper workings it is pyritic, and probably the iron oxide in the outcrop rocks is largely the result of weathering of pyrites. The gold is mainly in the cementing material, and is rugged and crystalline, being therefore evidently deposited from solutions traversing the old gravel layer, and not simply alluvial gold in an old cemented gravel. The occurrence

seems to be similar in all essential respects to that of the "banket" reefs of the Witwatersrand field in South Africa. The impregnation of the conglomerate with gold is rather probably quite local, but remembering the great distance over which the South African bankets have been proved to be auriferous, there is reason to hope that these conglomerates also may prove to carry gold over large areas. It is to be remembered that the Nullagine series contains numerous and very extensive beds of lavas, pointing to widespread and long continued volcanic activity during their formation, and this was doubtless accompanied with much fracturing of the earth's crust and hydro-thermal action, which might reasonably be supposed to be favourable, in accordance with the most generally accepted theories of ore formation, for the impregnation of permeable gravels with pyrites and gold.

The conglomerate raised from the mines was taken by tramways to a 20-head stamp battery and there crushed, but the battery has since been removed. The methods of raising and forwarding the stone to the mill seemed to me capable of very considerable improvement if work were resumed, and cheap handling and crushing would be of the greatest importance in making the mines profitable. It seems worth suggesting that some experiments should be made on this boulder conglomerate to see if it could not be disintegrated without crushing all the big hard stones. If these could be freed from the cementing material adhering to them by a process of attrition in revolving disintegrating cylinders the quantity of stuff requiring crushing and amalgamation could be greatly reduced, and as the hard boulders apparently contain no gold this would have much to recommend it. It did not seem to me that the cementing material was too firm for some such treatment.

The working of these conglomerates did not prove profitable, and the owners ceased operations pending such improvement of working conditions as would enable them to resume them with reasonable expectation of success. It is clear from the results already obtained that there is here a very important low-grade proposition. But though enough has been done to show that it deserves most serious consideration, it appears to me that before again attempting to work it on the large scale which its importance warrants, it would be judicious to carry out some systematic prospecting of the auriferous area where the deposit is more deeply buried in order to get a more accurate estimate of its average value, to determine more exactly its real shape, and so obtain data from which to lay out the scheme of mining to best advantage, and to ascertain, if possible, under what conditions there is the best expectation of finding the richer portions of the ore. It is rather probable that the shape of the deposit may favour the concentration of gold in certain parts of it, for example, in the bottom of the synclines



(trough-like or basin-shaped bends), and that faults dislocating and cutting the strata may exercise considerable influence on the deposition of the gold. A certain amount of valuable information could be got rapidly by diamond-drill borings, but as the deposits are not as a rule deeply buried it would be preferable in this case to adopt the slower and more expensive, but much more satisfactory method of sinking prospecting shafts and driving therefrom. These would be of service later on as mullock shafts for sending down filling for the stopes and air shafts for ventilation of the workings, and would enable bulk tests to be obtained from various parts of the deposit, and the conditions of occurrence of the best ore to be closely studied. A comparatively small expenditure in this sort of work would enable the average value of the ore to be very satisfactorily proved, so that extensive operations could be begun with reasonable certainty as to tonnage and value that would be returned.

Should the workings of these auriferous conglomerates prove commercially successful there will be a wide field for prospecting by drilling in the very extensive areas of the Nullagine series of beds scattered over the Pilbara and West Pilbara Goldfields, especially where the conglomerates rest upon the proved auriferous older rocks of the Warrawoona and Mosquito Creek formations. Where the base of the Nullagine beds is cut into by erosion of the surface, alluvial gold in the gullies traversing them will doubtless usually afford proof of their auriferous nature, but in many places the basal beds do not appear at surface, and boring will be the easiest method of testing them.

*Diamonds.*—The occurrence of diamonds in the Nullagine conglomerates is referred to fully in the Geographical Survey Bulletin No. 20. The stones are small, but the discoveries are quite well authenticated. Prospectors working alluvial detritus from the conglomerate beds throughout the goldfield should therefore keep a sharp look out for diamonds as well as for gold.

#### MIDDLE CREEK—20-MILE SANDY—AND MOSQUITO CREEK DISTRICTS.

Auriferous reefs in the sedimentary beds of the Mosquito Creek formation of the Geological Survey are found commonly as we go east from Nullagine, but few leases have been taken up until the Middle Creek group is reached, about 12 miles from Nullagine, from which centre eastward to Mosquito Creek mines have been opened on numerous reefs at short distances apart. The time at disposal during our visit only allowed a very flying look at a few of the more prominent mines, without any chance of more than the most cursory examination of them, so the following notes on these districts are necessarily very incomplete. The district has, however, been examined at more leisure by the Government Geologist, whose report and maps have been published in Geological Survey Bulletin

No. 15, to which account of the district my notes may be regarded as supplementary.

*Blue Spec* (164L).—No work had been done in this mine for some time when we visited it, but it was thought worth looking at on account of the large quantity of stibnite carried by the reef. The shaft is said to be down 70 feet. There are two parallel reefs, 20 to 30 inches wide, some seven or eight feet apart, running north 80deg. east. Mr. Kelly, the manager of the 20-Mile Sandy State Battery, informed me that the lode could be traced for more than a mile, and that there had been several crushings from it, which showed it to carry good values in gold. One crushing of quartz, fairly free from stibnite, returned about 2oz. gold per ton, but two others, carrying a good deal of stibnite, gave bad milling results. One yielded 4dwts. gold per ton by amalgamation on the battery plates, while assays showed 35dwts. in the tailings, and another gave 12dwts. per ton on the plates and assayed 25dwts in the tailings. The ore lying about the surface at the shaft is strongly charged with stibnite and some oxide of antimony, and a lot of fairly pure solid antimony ore could be picked out which would be worth treatment for this metal if it could be cheaply exported. Under present circumstances it is valueless, and only a detriment to the recovery of the gold in the reef. I took a sample of the cleaner antimonial ore from the dumps, which was found on assay by the Government Mineralogist and Assayer in Perth to contain 37.30 per cent. antimony, gold 3oz. 1dwt. 16grs. per ton, and silver, 2dwts. 4grs. per ton. The market value of antimony ore has lately fallen heavily, from over £20 per ton, for 50 per cent. ore, in May last, to £10 per ton at the end of July. At the latter rate the gross value of ore of the above assay would be about £19 a ton—cartage to Port Hedland, however, costs about £16 per ton, or with freight to Fremantle, £19 a ton, so it is evident that ore of the above excellent value cannot be exported profitably at present.

*Barton* (106L).—On this lease there are two strong quartz reefs cropping out very distinctly, running north-north-easterly and dipping east-south-east about 65 degrees. The main reef is traceable on surface for over 1,200 feet in length, the outcrop often standing up very boldly, three feet to 12 feet wide. Considerable work has been done on this reef, and the mine has been provided with steam winding machinery, poppet heads, and a 10-head battery with cyanide plant, and another 5-head battery on the ground but not erected. I was informed that the whole of the mining development and machinery had been paid for out of the produce of the mine. The main shaft is a vertical one 180 feet deep, and a bottom level has been opened out along the reef at 160 feet. In this the lode is up to 20 feet in width between its walls, but much of this is soft mullocky material. There is a big body of quartz, but poor at this

point, and the drive was being pushed on to the southward to get under the good ore shoot worked in the shallower levels. The ground proved to be heavy and treacherous, the slate being soft just below the water-level, though doubtless it will be harder in depth, and required much timber. As the round timber for this work was costing 1s. per lineal foot delivered on the mine, timbering was a heavy expense. There is another shaft on the reef, on the shoot of gold. It is 110 feet deep on the underlay, and a winze has been sunk another 50 feet. The reef has been stoped out from three feet to five feet wide, only portion of the whole "formation" being taken. It lies parallel to the stratification of the enclosing slate country, but is nevertheless in my opinion without question a true fissure reef, the well-smoothed walls, frequent occurrence of crushed and squeezed "mullock" between them, and enclosures of slate in the quartz all going to prove this very clearly. The returns from this mine to end of April, 1907, have been 3,327.65 tons crushed for 4,193.63 ounces of fine gold. The battery has been of much service to other mines in the district, crushing for them when required.

When visiting the Barton mine Mr. O'Brien, one of the owners, showed us some very nice copper ore from the Little River district. The lode is said to be up to 15 feet in width, and traceable for a considerable distance. The samples shown contained some excellent oxide of copper ore fit for export, if the district were rendered more accessible.

*All Nations* (G.M.L. 166L).—A very considerable amount of work has been done on this reef, but the old workings, about 50 or 60 feet deep, are now inaccessible. The reef strikes about north 5deg. east. Geological Survey Bulletin No. 15 records 401.50 tons of stone crushed for 868.11ozs. of gold to end of 1903, but I was informed on the ground that about 1,000 tons in all had been crushed for a yield of over 2ozs. per ton. The present owners are sinking a new shaft 200 feet deep to reopen this mine, and are receiving assistance from the Government in this work at the rate of £1 for £1 up to from £1 to £2 5s. a foot, according to the depth.

*Little Wonder* (136L) and *Eureka* (147L).—These mines adjoin one another on a reef running about west-north-west and east-south-east, and have been worked somewhat extensively, but without machinery. The Little Wonder workings are down to the 160 feet level, and a winze has been sunk 30 feet deeper. Water is met with at about 174 feet, the influx into the winze being said to be about 100 gallons per hour. The lode appeared to me to be a much more extensive affair than the somewhat irregular veins and bodies of quartz that have been mined, being apparently a wide shattered "formation" between main walls 20 to 40 feet apart. Between



the main walls there are several other smoothed and striated faces or "walls" running in various directions and differing much in dip, and the quartz has been formed along them, and in irregular bodies throughout the shattered mass of country enclosed between the main walls. The prospectors have laboriously followed the more valuable veins of quartz, as was doubtless the best policy in the earlier stages of the mine, but now that the nature of the occurrence is visible it seems more advisable to drive boldly along the course of the "formation," with frequent crosscuts from main wall to main wall, so as to open up the bodies of ore in a way that will allow of cheap mining. At present a very great deal of handling is necessary underground on account of the irregular shape of the workings. Some very rich ore has been got from this mine, crushings having returned as much as 13ozs. per ton. Mr. O'Driscoll, one of the owners, gave me returns of 10 crushings amounting to 769 tons which yielded 3,190 ounces of gold by battery amalgamation. From one crushing of 113 tons, which gave 138 ounces from the plates, there was a further return of 32 ounces by cyanide treatment. The officially recorded figures show 732 tons crushed for a return of 3,173.28 ounces of fine gold to April 30th, 1907. At the time of my visit there was some fair stone at surface, in which gold could be seen readily. This mine appears to me to have very fair chances of becoming an important one if opened up in a systematic manner. The quartz from the winze contains some pyrites and other sulphides.

*The Bow Bells and Round Hill* mines were not being worked at the time of our visit, and were not visited. They are said to have stone worth 15s. to 17s. per ton over the battery tables, but which is too poor for working under present circumstances.

*State Battery 20-Mile Sandy.*—Most of the crushing for the district is done at the State battery, which consists of 10 stamps and cyanide plant; crushing charges are 14s. to 18s. per ton. Cartage charges are heavy, one of the mines 10 miles distant, for example, having to pay 22s. a ton to send stone to the battery. In consequence of the high costs of working the ore must be of good grade to pay expenses. I was told of one mine close to the battery which had to be abandoned as unpayable although the returns from crushings were 12dwts. per ton over the tables, and the tailings yielded 5dwts. per ton to cyanide treatment. Some very rich ore has been received at the mill occasionally, one parcel of three tons from the Castlemaine mine yielding 860.77 ounces of fine gold by plate amalgamation, and 1.45 tons of sands for cyanide treatment assaying 43oz. 16dwt. of gold per ton before treatment. This mine has returned 1097.02 ounces of fine gold from six tons crushed during 1905 and 1906.

The following table shows the returns from the 20-Mile Sandy Battery.

STATE BATTERY—20 MILE SANDY.  
Returns to 31st May, 1907.

Year.	Mine.	Tons crushed.	By Amalgamation.	By Cyanide.	Total.	Tons crushed.	Grand Total.
		ozs. dwts. grs.	ozs. dwts. grs.	ozs. dwts. grs.	ozs. dwts. grs.		ozs. dwts. grs.
1905	All Nations	39.5	49 0 0	9 1 21	58 1 21	39.5	58 1 21
1905	All Nations Extended	20.5	26 18 0	3 2 4	30 0 4	70.0	163 0 7
1905	Do.	49.5	118 4 0	14 16 3	133 0 3		
1905	Ard Patrick	215.0	356 5 0	83 13 15	439 18 15		
1906	Do.	51.0	353 12 0	48 17 2	401 9 2	305.0	1,027 2 17
1907	Do.	39.0	155 6 0	29 19 0	185 5 0		
1905	Bow Bells	130.0	133 14 0	16 13 18	150 7 18	130.0	150 7 18
1906	Boulder	3.5	6 12 20	0 7 12	7 0 8	3.5	7 0 8
1906	Blue Spec	22.0	4 10 12	0 0 0	4 10 12	22.0	4 10 12
1905	Castlemaine	3.0	828 0 0	52 14 6	880 14 6		
1906	Do.	3.0	223 2 0	18 18 0	242 0 0	9.0	1,129 12 6
1907	Do.	3.0	6 4 0	0 14 0	6 18 0		
1905	Central	145.0*	101 17 0	15 8 10	117 5 10	178.0	174 1 2
1906	Do.	33.0	44 4 0	12 11 16	56 15 16		
1907	Central West	10.0	37 9 0	5 0 12	42 9 12	10.0	42 9 12
1905	Cowra & Brusher	35.0	20 7 0	2 19 23	23 6 23	35.0	23 6 23
1905	Chris. Watson	34.5	57 6 0	10 12 0	67 18 0	34.5	67 18 0
1907	Campbell's Hill	67.0	42 10 0	10 3 8	52 13 8	67.0	52 13 8
1906	Dreum	29.5	53 17 0	3 5 0	57 2 0	29.5	57 2 0
1905	Endeavour	51.5	31 0 0	14 2 7	45 2 7	51.5	45 2 7
1905	Eureka	34.0	38 0 0	5 4 3	43 4 3		
1907	Do.	10.0	5 9 0	0 10 2	5 19 2	44.0	49 3 5
1906	Eupulation	12.5	49 4 0	5 2 0	54 6 0	29.0	78 5 4
1907	Do.	16.5	21 13 0	2 6 4	23 19 4		
1905	Eldorado	3.0	33 17 0	0 15 0	34 12 0	3.0	34 12 0
1907	Empcor	31.0	21 6 0	3 1 5	24 7 5	31.0	24 7 5
1905	Forlorn Hope	20.0	17 0 0	3 7 18	20 7 18	20.0	20 7 18
1903	Federation	15.0	17 11 0	1 18 2	19 9 2	15.0	19 9 2
1905	Galena	25.0	12 19 0	0 0 0	12 19 0	25.0	12 19 0
1905	Galtee More	280.0	607 13 0	59 3 4	666 16 4		
1905	Do.	168.5	338 6 0	40 16 17	379 2 17	529.5	1,457 13 1
1906	Do.	81.0	373 4 0	38 10 4	411 14 4		
1907	Do.	7 16 0	0 0 0	0 7 9	8 3 9	4 0	8 3 9
1905	Great Divide	4.0	7 16 0	6 13 16	50 6 6	68.0	50 6 6
1906	Goodwin	68.0	43 12 14	0 6 0	50 6 6		
1906	Glenallan	3.0	3 12 0	0 6 0	3 18 0	3.0	3 18 0





*Ardpatrick G.M.L. 143.*—The main shaft of this mine is down 135 feet, and there is a winze 75 feet below the bottom level. No water of consequence has been encountered in sinking. There is also a shaft 80 feet deep east of the main shaft ; at the 60 foot level in this the lode is seen to run east and west, and is about three feet wide between smooth walls which cut obliquely across the foliation of the enclosing country schist. The quartz is from six inches to two feet six inches in thickness, and often has a considerable quantity of scheelite (tungstate of lime) mixed with it and usually closely associated with the gold. The scheelite might be worth taking some trouble to save by concentration if there were a railway to Marble Bar, but at present it is valueless. The Ardpatrik reef is rather a small one, but it has given some very good returns, the official records being :—

		Tons crushed.	Fine ounces of Gold.
To end of 1906	...	314.00	gave 1098.48
„ „ May, 1907	...	39.00	„ 148.06
Total	...	353.00	„ 1,246.54
of Value £5,295.			

*Galtee Moore (79L) and (145L).*—This mine has a main shaft 212 feet deep, 177 feet being vertical, and 35 feet on the underlay of the reef, and a second vertical shaft 100 feet deep. This reef runs about east and west, and seemed to me to be very similar to the Little Wonder Reef above mentioned, viz., a large jumbled “formation” between two main smoothed walls, which are nearly vertical. The country is slate and sandstone. The quartz occurs in rather irregular strings, lenses and bunches in the shattered zone between the main walls, doubtless following more or less the openings between the masses of country with which the main fissure was originally roughly filled or which were formed between them from time to time through faulting movements of the walls. The prospectors have stuck closely to the quartz, and in consequence their workings are very irregular in shape, and a great deal of handling of the ore is required underground. The mine has a good record of production, and seems worth opening up systematically. On surface the outcrop has been worked eastward from the main shaft for about 300 feet, yielding some fair crushings. The recorded returns from this mine have been 1,252 tons crushed for 2,959.76 ounces of fine gold, to 30th April, 1907

In the vicinity of the Galtee Moore and Ardpatrik mines there are several other mines, which were not visited by our party, forming a belt of more or less parallel lodes which seem worthy of attention.

*Mosquito Creek Battery.*—At Mosquito Creek there is a rather light and old fashioned 10-head battery with three crude cyanide vats. The battery well is 70 feet deep, sunk in a hard red granite,

which seems very suitable for ornamental purposes. The water supply is not very plentiful and gave out almost entirely in a recent very dry season. A Government well is about 100 yards distant. Firewood costs 35s. a cord at this battery.

*Bell's Battery* is close to the workings on the Parnell Reef. It has 10 heads of somewhat light stamps and a cyanide plant.

*Parnell Mine* (95L).—The Parnell reef is a strong fissure lode running nearly east and west, traceable for about half a mile in length, and having several shafts sunk upon it, the main one being 190 feet deep, as is also that on the Federal Lease (109L) to the east of the Parnell, on the same reef. The main ore shoot according to the plans of the mine pitches easterly. At the time I visited it tributors were at work close to the surface, taking out some very shallow stone that had been left. The reef is a big strong one, over six feet wide, and looked very well in these shallow workings, but I did not see the lower parts of the mine. The manager had about 200 tons of ore at grass which he expected would yield about an ounce to the ton. This ore was raised by two men in ten weeks. The official record shows a total of 2,220.35 tons crushed from the Parnell leases to April 30th, 1907, for 2,158.98 ounces of fine gold.

*Nichol's Reward*.—This old mine lies east of the Parnell, but the reef in it is somewhat north of the Parnell reef line showing either that the latter is heaved to the north by a fault or a parallel fracture *en echelon*, as is so common in these goldfields. The main shaft is 115 feet deep, and there is another one about 60 feet further east. Two men had taken up this ground again and were working on a vein of 18 inches to two feet of stone said to be worth about an ounce of gold to the ton.

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## NULLAGINE DISTRICT.

The following Table showing the Gold Production of the Nullagine District of the Pilbara Goldfield is adapted from the latest available Statistical Returns to the Mines Department, and shows the Total Recorded Production to 30th April, 1907.

Mining Centre.	Number of Lease.	Registered Name of Company or Lease.	Area in Acres.	Total for 1904.				Total for 1905.				Total for 1906.				Total for 1907 (to 30th April.)				Total Gold Production.				
				Alluvial.	Dollied, and Specimens.	Ore treated.	Gold therefrom.	Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	
				Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.
Elsie	Do.	Voided leases	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	408.25	1,323.85	
Mosquito	Do.	Sundry claims	12	..	..	8.00	34.27	..	..	215.00	658.72	..	..	91.00	405.49	..	..	..	..	..	..	20.00	16.85	
Do.	Creek	Ard Patrick	42	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	314.00	1,098.48	
Do.	Do.	Bell Exploration Company Ltd.	131L, 135L	12	..	..	..	..	..	..	..	..	..	29.50	50.71	..	..	..	..	..	..	..	..86	
Do.	Do.	Dream	169L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	29.50	50.71	
Do.	Do.	(Federal	109L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	48.00	56.46	
Do.	Do.	Galtee Moore) Leases	79L	18	..	102.00	439.36	..	..	..	..	..	..	..	..	..	..	..	..	..	..	586.00	1,648.33	
Do.	Do.	Land's End	79L, 145L	6	..	..	..	..	..	280.00	622.13	..	..	230.00	335.80	..	..	156.00	353.50	..	..	..	666.00	1,311.43
Do.	Do.	Land's End East	159L	..	..	..	..	..	..	10.70	122.70	..	..	10.00	47.47	..	..	..	..	..	..	..	20.70	170.17
Do.	Do.	Latest Surprise	162L	..	..	..	..	..	..	..	..	..	..	6.00	7.53	..	..	..	..	..	..	..	6.00	7.53
Do.	Do.	Monte Carlo United	127L	Surr.	..	..	..	..	..	122.00	168.98	..	..	..	cy. 8.72	..	..	..	..	..	..	..	310.00	535.46
Do.	Do.	Off Chance	141L	6	..	12.50	23.16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	12.50	23.16	
Do.	Do.	(Parnell)	144L	..	..	21.00	31.59	..	..	38.00	87.66	..	..	162.00	211.77	..	..	..	..	..	..	221.00	331.02	
Do.	Do.	(Parnell leases)	95L	..	..	1,159.00	882.62	..	..	656.00	853.47	..	..	..	..	..	..	..	..	..	..	357.35	368.08	
Do.	Do.	Parnell North	95L, 109L, 125L, 131L, 135L	Fld.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1,815.00	1,738.09	
Do.	Do.	Rattler	148L	Fld.	..	24.50	28.58	..	..	29.50	62.26	..	..	..	..	..	..	..	..	..	..	66.00	71.07	
Do.	Do.	Voided leases	150L	..	..	17.00	29.43	..	..	..	..	..	..	..	..	..	..	..	..	..	..	46.50	91.79	
Do.	Do.	Sundry claims	..	..	..	407.00	523.50	..	166.47	38.00	128.05	..	..	46.00	65.23	..	..	43.00	24.12	..	166.47	1,668.44	2,424.02	
Nullagine	Do.	Barton	106L	18	..	544.00	1,269.18	..	..	610.00	323.12	..	..	292.00	249.38	..	..	..	115.02	..	..	3,327.65	4,193.63	
Do.	Do.	Blue Spec	164L	12	..	..	..	..	..	..	..	..	..	22.00	4.44	..	..	..	..	..	..	22.00	4.44	
Do.	Do.	British Exploration of Australasia, Ltd.	119L, 120L, 121L, 122L	96	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	777.00	88.93	
Do.	Do.	Castlemaine (Grant's Hill)	154L	Fld.	..	..	..	..	..	3.00	860.77	..	..	3.00	236.25	..	..	3.00	5.98	..	..	9.00	1,103.00	
Do.	Do.	Mundalla	122L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1,658.00	701.61	
Do.	Do.	Onion	156L	Surr.	6	..	..	..	..	..	..	..	..	17.50	231.89	..	..	..	..	..	..	17.50	231.89	
Do.	Do.	Voided leases	140L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5.75	9.45	
Do.	Do.	Sundry claims	..	..	12.26	302.25	541.60	..	7.70	256.50	410.33	..	23.26	99.50	320.06	..	..	92.50	69.42	104.70	91.23	3,705.25	7,732.17	
20-Mile Sandy	Do.	Central	137L	Fld.	..	..	..	..	..	145.00	104.66	..	..	..	..	..	..	..	..	..	..	165.75	155.42	
Do.	Do.	Eureka	147L	Fld.	..	..	..	..	..	34.00	40.51	..	..	..	..	..	..	..	..	..	..	44.00	45.64	
Do.	Do.	Harp	161L	Fld.	..	..	..	..	..	..	..	..	..	21.00	35.20	..	..	10.00	5.13	..	..	21.00	35.20	
Do.	Do.	Henry George	158L	Fld.	..	..	..	..	..	..	..	..	..	22.00	40.74	..	..	..	..	..	..	22.00	40.74	
Do.	Do.	Last Hope	151L	6	..	..	..	..	..	3.00	5.11	..	..	..	..	..	..	..	..	..	..	3.00	5.11	
Do.	Do.	Little Wonder	136L	..	..	249.70	351.88	..	..	113.30	335.71	..	..	25.00	33.55	..	..	..	2.44	..	..	732.00	3,173.28	
Do.	Do.	Little Wonder West	138L	10	..	18.50	21.89	..	..	78.00	120.65	..	..	75.00	176.07	..	..	..	22.69	..	..	171.50	341.60	
Do.	Do.	Mountain Maid	167L	12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	81.00	198.99	
Do.	Do.	Round Hill	148L	Fld.	..	..	..	..	..	..	..	..	..	40.00	38.42	..	..	..	..	..	..	40.00	38.42	
Do.	Do.	Voided leases	100L	Fld.	..	..	..	..	..	6.00	4.88	..	..	..	..	..	..	..	..	..	..	6.00	4.88	
Do.	Do.	Sundry claims	..	..	11.40	121.40	243.55	..	2.87	463.85	772.39	..	..	261.00	427.46	..	..	59.00	61.87	..	14.36	1,472.15	2,605.26	
From District generally:—				..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Sundry parcels treated at:—				..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	651.02	
Barton Cyanide Works				..	..	..	cy. 77.86	..	..	..	cy. 573.16	..	..	..	..	..	..	..	..	..	..	..	138.88	
Parnell Battery				..	..	..	..	..	..	..	cy. 138.88	..	..	..	..	..	..	..	..	..	..	..	124.65	
State Battery, 20-Mile Sandy				..	..	..	..	..	..	..	..	..	..	..	..	cy. 124.65	..	..	..	..	..	..	..	
Various Works				..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	38.50	
Reported by Banks and Gold Dealers				378.06	..	..	..	354.42	10.14	..	..	211.46	..	..	..	70.10	..	..	..	..	3,972.12	22.50	..	
Total				378.06	23.75	2,986.85	4,498.47	354.42	187.18	3,101.85	6,397.98	211.46	23.26	1,533.50	3,220.21	70.10	..	363.50	660.47	4,076.82	308.52	24,088.74	43,286.68	

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## OTHER CENTRES NOT VISITED.

Lack of time prevented our party from visiting several other centres throughout the goldfield which are of much interest, but most of which have already been fully described in the Government Geologist's reports in *Geological Survey Bulletins* Nos. 15, 20, and 23.

*The Mount Elsie and Boodalyerri districts* are described in *Bulletin* No. 15, which shows that the Elsie reef produced from 1899 to 1902 1,413.82 ounces (equal to 1,323.85 ounces fine) of gold from 408.25 tons of stone crushed, being a yield of 3.46 ounces per ton. Sundry other claims have given 16.85 fine ounces from 20 tons crushed. The Golden Granite mine at Boodalyerri has crushed 06.25 tons for 490.04 fine ounces of gold, or at the rate of 4.61 ounces (fine) per ton, besides giving 76.11 ounces from specimens allied, and the Boodalyerri centre altogether has a record of production of 587.86 fine ounces from 120.25 tons of ore crushed and 148.85 fine ounces from specimens. According to the current local belief as expressed to us by various well-informed people at Marble Bar and Nullagine, there are numerous low-grade reefs in the Boodalyerri district that might be worked if facilities were improved.

*The Bamboo centre* is also described in *Geological Survey Bulletin* No. 15, and is notable for possessing in the *Bulletin* mine the deepest mining shaft in the Pilbara goldfield, viz., 400 feet, and that is said to be the longest continuous shoot of ore yet worked. Some of the ore which was shown to me at Marble Bar was very rich in gold and charged with a good deal of sulphide of antimony. The mine is now working again.

The following table of production to end of 1903 is taken from *Geological Survey Bulletin* No. 15, page 61.

*Synoptical Table showing the yield of the Bamboo Reefs.*

Name of Reef, etc.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Bamboo ... ..	4.00	8.40	2.10
Bamboo Queen Q.C. 131 ... ..	30.00	63.85	2.13
Bamboo Queen and Reward ... ..	1,390.50	2,436.80	1.75
Bulletin ... ..	3,359.50	6,425.85	1.91
Mount Prophecy ... ..	1,658.00	4,072.60	2.45
Desperandum ... ..	169.00	147.85	.87
Pilbara Syndicate ... ..	96.00	119.00	1.23
Pilbara Goldfields, Ltd. ... ..	2,297.75	3,176.85	1.81
Smier ... ..	40.00	88.00	2.20
Selected Q.C. 127 ... ..	34.00	74.00	2.18
Manian ... ..	1,433.00	3,402.40	2.36
Wave ... ..	114.50	128.25	1.12
Sundry claims ... ..	72.00	300.50	4.17
Total ... ..	10,698.25	20,444.35	1.91



*Since 1903 the official record gives to end of 1906:—*

	1904.				1905.				1906.				Total to end of 1906.			
	Dollied and Specimens.	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Dollied and Specimens.	Ore treated.
161 Bulletin (formerly Bamboo Consolidated G.M. Co.)	Fine ozs.	Tons.	Fine ozs.	Fine ozs.	Tons.	Fine ozs.	Fine ozs.	Tons.	Fine ozs.	Tons.	Fine ozs.	Fine ozs.	Tons.	Fine ozs.	Fine ozs.	Tons.
	..	(cy.)	251.31	..	115.00	213.88	..	100.00	..	100.00	177.18	..	3,544.50	6,423.77	..	3,544.50
Voided leases ..	..	..	..	..	..	..	..	..	..	..	..	..	7,202.75	10,318.50	..	7,202.75
Sundry claims ..	116.75	8.00	102.22	2.95	..	..	2.95	..	..	..	..	119.70	144.00	454.40	..	144.00
	116.75	8.00	353.53	2.95	115.00	213.88	..	100.00	..	100.00	177.18	119.70	10,891.25	17,696.67	..	10,891.25

*Talga-Talga District* is described in *Geological Survey Bulletin* No. 15, from which the following table of returns has been taken:—

*Synoptical Table showing the Yield of the Talga Talga Reefs.*

Year.	Name of Lease, etc.	Ore crushed.	Gold therefrom.	Rate per ton.	Total ore crushed.	Total gold therefrom.	Average rate per ton.
		tons.	ozs.	ozs.	tons.	ozs.	ozs.
1898	General, G.M.L. 485 .. ..	43.00	44.60	1.03			
1899	Do. .. ..	11.50	7.90	.68	54.50	52.50	.96
1897	Jubilee G.M.L. 458 .. ..	91.00	137.00	1.50			
1898	Do. .. ..	33.00	45.90	1.39	124.00	182.90	1.47
Previous to 1897	McPhee's Reward, Ltd., G.M.L. 55	367.00	957.00	2.60	367.00	957.00	2.60
Previous to 1897	Star of the North G.M.L. 124	18.50	19.00	1.03			
1897	Do. .. ..	97.00	115.74	1.19	115.50	134.74	1.16
1898	N.W. Goldfields, Ltd., G.M.L. 170	26.00	33.00	1.26	26.00	33.00	1.26
Previous to 1897	Sundry claims .. ..	96.00	456.00	4.75			
1899	Do. .. ..	45.00	89.95	1.99			
1901	Do. .. ..	9.25	24.10	2.60			
1902	Do. .. ..	54.40	82.09	1.50	204.65	652.14	3.18
	Totals .. ..				891.65	2012.28	2.25

The official statistical returns to end of 1906 show only one later record, the Zephyr G.M.L. 616, having returned in 1904 83.83 fine ounces from dollied specimens, and 0.84 fine ounces from three tons of ore crushed.

The totals to end of 1906 are given as—

Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.
ozs. fine. 50.26	ozs. fine. 152.82	Tons. 779.15	fine ozs.. 1496.23

It would seem from this that the table in the *Geological Survey Bulletin* includes some yields not taken into account in the statistical record of returns reported to the Mines Department.

A sample of galena from a reef at Talga Talga given to me at Marble Bar by Mr. Riches, Inspector of Mines, has been assayed in the Geological Survey Laboratory with the following result:—

Lead (wet assay) ... 33.76 per cent.  
ozs. dwts. grs.

Gold ... 0 1 11 (0.073 oz.) per ton.

Silver ... 8 11 8 (8.567 oz.) per ton.

This does not show a high value in silver per unit of lead.

In *Bulletin* No. 15 also appear description of the *North Pole* and *Lalla Rookh* centres from which the following tables are quoted :—

*Synoptical Table showing the Yield of the Lalla Rookh Reefs to end of 1903.*

Name of Reef, etc.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Bergamini G.M.L. 606 ... ..	186'00	101'00	'54
Kitchener G.M.L. 569 ... ..	38'50	37'10	'96
Lalla Rookh R.C. 112 ... ..	6,277'55	7,414'56	1'18
Sundry Claims ... ..	30'45	50'30	1'65
Total ... ..	6,532'50	7,602'96	1'16

During 1904, 1905, and 1906, the tailings on the *Lalla Rookh* mine were cyanided, yielding 2,078.79 fine ounces of gold. The total production of the *Lalla Rookh* centre to end of 1906 is given by the official statistics as 6,532.50 tons crushed for a total return of 7,717.51 ounces of fine gold.

*Synoptical Table showing the Yield of the North Pole Reefs to end of 1903.*

Name of Reef, etc.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
North Pole Democrat G.M.L. 453 ...	392'00	268'00	'65
Try Again G.M.L. 575 ... ..	24'00	56'40	2'35
Total ... ..	416'00	324'40	'78

There were no returns in 1904, 1905, and 1906, and the total to end of 1906 is given in the Statistical record as 416.00 tons crushed for 277.02oz. of *fine* gold.

The fields which were not visited by our party seem from the Geological Survey descriptions to be quite similar to the other Pilbara gold districts in geological structure and mode of occurrence of the gold, being belts of greenstone schists of the Warrawoona series, usually close to a contact with granite, traversed by numerous dioritic and granitic dykes, containing large bars of jasperoid quartzites, and having the gold in quartz reefs of fissure vein type lying usually more or less parallel with the lamination of the schist.

#### ASBESTOS.

It has been known for some years that good specimens of chrysotile asbestos had been reported from the Pilbara Goldfield, but there seems to have been very little interest taken in the discovery, and no public information was available as to the precise locality in which the mineral existed until about two years ago, when the matter was taken up by Mr. Herbert Soanes. He found that the place where the asbestos had been got was in the



rough hilly country to the west of Cooglegong, and obtained and sent away to London about two tons of hand-picked mineral. "The Pilbara Asbestos Co., Limited," was then formed with a capital of £60,000 to acquire and work the deposits. From the prospectus of this company it appears that the sample of fibre shipped was "favourably received by experts, and one ton (2,000lbs.) of different qualities was sold on its arrival for experimental treatment at £35." The following letter from the well-known firm of Messrs. Bolling & Lowe, bearing on the value of the mineral, is also quoted in the prospectus:—

"2, Laurence Pountney Hill, London E.C.,  
2nd February, 1907.

*To the Directors of the Pilbara Asbestos Company, Limited.*

Gentlemen,—Judging from the sample of asbestos submitted to us by Mr A C. Gardiner, we have no hesitation in saying that the sample is as good as, if not better than, any No. 1 crude asbestos we have ever seen, and if the bulk of your production is equal to that sample we have little doubt that we could sell from 500 to 1,000 tons per annum through our various customers. We consider the price would range from £25 to £50 a ton delivered c.i.f., in European ports, and we could to-day sell a fair quantity of such material as is indicated by your sample at the latter figure or a trifle over.

We remain, yours faithfully,  
(Sgd.) BOLLING & LOWE."

Samples of the mineral received in Perth show it to be very good chrysotile asbestos, of good colour and very silky lustre, and divisible by rubbing into very fine fibres which exhibit great toughness when roughly spun. Some of the natural bundles of fibre are a little brittle when the fibre has not been separated, but by a bruising crushing they separate out into good tough fibre. Some of the fibres are as much as six inches in length, which is very good indeed. The mineral has every appearance of being of excellent quality.

As there was not time during our visit to the fields for the Hon. the Minister and myself to visit this discovery. Mr. P. C. Riches, District Engineer and Inspector of Mines, was instructed to make a report upon it, which he has done as follows:—

"I left Marble Bar on 10th instant in company with Messrs. Gardiner and Soanes, and arrived at the asbestos mine on the 12th inst. The mine is located in a very rough piece of country about 15 miles due west of Cooglegong and about 21 degrees 30 minutes S. Lat. (obsd.). We were unable to get within 2½ miles with the buggies so had to walk the remaining distance.

The asbestos lodes occur in a belt of serpentine country, running north-east and south-west, that lies more or less in a valley bounded on the North and South by large jasper dykes. The

serpentine belt varies in width from 20 chains to about 5 chains, where it passes through a steep gorge at the south-west end of the traverse, after passing through this gorge it again widens out and extends with varying widths for another mile.

The asbestos lodes so far traced are two parallel lodes lying about a chain and a-half apart, and can be traced along the surface for about 30 chains, they appear to follow a diorite bar running parallel with it about ten feet away; the northern lode lies on the north side of the diorite while the southern lode is on the south side. It may possibly be found later that the whole of the country between these bars consists of diorite, but on the surface it appears to be serpentine, the bars themselves being only a few feet wide.

I found on arrival that very little prospecting work of any sort had been done, in fact the only work was a shaft 6ft. x 3ft. 6in. by 23ft. deep, and a pot hole about 4ft. deep, these were sunk by Mr. Soanes some 18 months ago.

Mr. Gardiner let me have a couple of men and I at once set them to work opening up the lode at various points, the shaft was also cleaned out and I then proceeded to sample the lode in the shaft, and also at the places that I had opened up.

The asbestos occurs in the lode where exposed in the shaft in veins running from mere threads to a bunch 6 inches wide. The large lode sample I have sent you shows a fair average of the deposits carrying the asbestos as it neither shows the very small or the large seams, it also explains for itself the occurrence of the mineral. In the bottom of the shaft, and also in the western end the lode is very much split up and is not nearly so rich as in the stope about 9ft. from the surface, however, the whole of the lode exposed in the shaft would probably average about 20 per cent. of asbestos.

On the surface I had shallow trenches cut across the lode at intervals, and found that at a depth of 18 inches the lode for a distance of 12 chains averaged about 2ft. 6in. in width, containing about 15 per cent. of fibre. I was unable to trace the south lode any further than the point at which sample 19 was obtained, but it is probably only hidden with over burden that has shot down the hillside, the blank holes that I had sunk being all in made ground.

On the north lode no work of any sort has been carried out, but it can be traced along the surface in a similar manner to the southern lode and would probably open up in a corresponding manner, as it appeared to me to be identical with the south lode, both as regards width and fibre at the two spots that I had opened up.

At various places on the surface and distant some chains from the two lodes already mentioned, pieces of loose decomposed serpentine can be picked up with asbestos veins from a mere thread to an inch wide running through them (notably the high hill where samples 23 and 24 were obtained). These specimens are scattered about

in some places over a width of 30 feet. No lode can be traced on the surface and an opinion as to the value of the deposit cannot be given unless some prospecting work is carried out.

With regard to the statement contained in the prospectus of the Pilbara Asbestos Company, Limited, that there is 130,000 tons of high-grade asbestos available, Mr. Soanes assures me that he has never at any time expressed this opinion, and in support of his contention has handed me his report on the property.

It is utterly impossible for me to give any estimate of the quantity of fibre available, if by available is meant the quantity in sight then there is not, including what is in the dump, ten tons available. Until some development is done and it is ascertained whether the lodes and fibre live at a depth, and also the percentage of fibre in the lode at these depths, it is utterly impossible for anyone to form an opinion as to the value of the mine or the amount of the asbestos available.

I must say that the proposition strikes me as a very favourable one, and in my opinion is well worthy of some systematic development."

A peculiarity of this discovery of chrysotile asbestos is that in this case it is found in more or less defined lodes of considerable length, instead of ramifying irregularly through masses of serpentine as is the most usual mode of occurrence elsewhere. The lodes are doubtless of the "segregation-vein" type, but there seems no reason to doubt that they will be very persistent in depth. It is clear from their very considerable linear extension that the cause which has produced them has operated on a fairly large scale along what were probably lines of shearing stress in the rock, and any feasible theory of the formation of the mineral seems to necessarily include its persistency in depth as well as in length. As seen by Mr. Riches' report above, the veins are of fair size, and contain a large amount of fibre, the vein matter being rich rock from the asbestos miner's point of view. In F. Cirkel's pamphlet on "Asbestos, its occurrence, exploitation, and uses," issued by the Department of Mines of Canada—which country is the principal producer in the world of the chrysotile variety of asbestos—an example is given of a mine in Canada, in fairly good ground, breaking 130 to 150 tons of rock per day, which supplies 80 to 90 tons of rock for the mill. This returns about  $7\frac{1}{2}$  tons a day of marketable asbestos, being about  $91\frac{1}{2}$  per cent. of the rock milled and  $51\frac{1}{2}$  per cent. of the rock mined. Expenses per ton of asbestos at this mine are given as \$17.41 or £3 12s. 6d. Elsewhere in the pamphlet Mr. Cirkel says that the lowest percentage of milling rock in the Canadian mines is about 20 per cent., and the highest 70 per cent. of the total rock mined, the average being 30 per cent. to 60 per cent., and that the milling rock returns 6 to 10 per cent. of marketed asbestos. The annual export is about 30,000 to 35,000 tons of dressed mineral of all grades, worth about \$1,000,000, or say £208,000.



Most of the asbestos mining in Canada is open-cut quarrying, but there seems every reason to think that the greater richness in fibrous contents of the veins described above by Mr. Riches will much more than compensate for the greater cost of lode-mining. The discovery requires a good deal of opening up before there can be any certainty that it is one of much commercial value, but on present appearances it seems to be an extremely promising one, and is certainly worthy of thorough testing both as to the quantity of mineral obtainable and as to its quality for all manufacturing purposes for which it is used.

Some of the samples collected by Mr. Riches from close to the outcrop of the vein are much stained with oxide of iron, but this is only a superficial feature due to weathering, which will soon disappear in depth.

A sample of this asbestos received some years ago by the Government Mineralogist and Assayer from a former Registrar at Tambourah was analysed by him, and found to be practically identical in composition with Canadian and Italian asbestos, as shown by the following analyses :—

	Italian.	Canadian.	Tambourah.
	per cent.	per cent.	per cent.
Silica ... ..	40·30	39·05	42·98
Magnesia ... ..	43·37	40·07	39·92
Iron protoxide ... ..	...	...	{ 24
Iron peroxide ... ..	87	2·41	{ 1·68
Alumina ... ..	2·27	3·67	·44
Water ... ..	13·72	14·48	14·82
Total ... ..	100·53	99·68	100·08

According to Canadian authorities the largest bulk of the asbestos mined there is quite short, being between one quarter and one half inch in length. The mines usually first hand-dress their product, sending the longer fibre to cobbing sheds, where it is separated by hand into two grades, No. 1 measuring over  $\frac{3}{4}$  inch in length of fibre, and No. 2 exceeding  $\frac{5}{8}$  inch. The waste from this work and the rock containing short fibre are crushed, and the fibres separated from the crushed matrix rock by shaking screens, suction fans, and other devices. The mills produce three grades of product known as "long spinning fibre," "spinning fibre," and "paper stock." The prices per ton (of 2,000lbs.) in 1905 were about as follows :—

Hand-dressed, No. 1 Crude,	\$175 to \$200 or, say,	£36—£42
No. 2 "	110 " 125 "	23— 31
Milled, Fibre No. 1	75 " 80 "	16— 17
" No. 2	50 "	10
Paper Stock	20 " 25 "	4— 5

The Canadian production of all grades in 1905 was 50,670 short tons, valued at \$1,486,359, equal to an average value of \$29.33 or £6 2s. 3d. per ton.

## SUMMARY OF MINERAL PRODUCTION.

The following table gives a short general summary of the Mineral Production of the Pilbara and West Pilbara Goldfields as reported to the Mines Department to end of April, 1907 :—

	Pilbara.			West Pilbara.		Total.	
	fine ozs.	Value. £		fine ozs.	Value. £	fine ozs.	Value. £
Gold ...	128,015.12	543,770		16,219.86	68,897	144,234.98	612,667
Silver ...	574.01	72		...	...	574.01 tons.	72
Copper Ore ...	...	...		13,447.00	140,236	13,447.00	140,236
Tin Ore ...	3,202.69	262,285		...	...	3,202.09	262,285
Tantalite ...	85.60	11,569		...	...	85.60	11,569
Ironstone ...	...	...		100.00	300	100.00	300
Diamonds ..	(weight un- known)	24		...	...	(weight un- known)	24
Total	...	£817,720		...	£209,433	...	£1,027,153

Gold taken at £4.2477 per oz. fine ; Silver at 2s. 6d. per oz.

The figures are incomplete, a good deal of gold having been produced that has not been properly recorded, not to speak of some small parcels of tin, copper, and antimony ores known to have been raised which have not been included. The gold bullion entered for export and received at the Perth branch of the Royal Mint from the Pilbara and West Pilbara Goldfields to end of April, 1907, amounts to 230,406.47 fine ounces, or no less than 86,171.49 ounces of value £366,031 more than the total of 144,234.98 fine ounces reported to the Mines Department. The silver returns are also very deficient, that alloyed with the gold not appearing in the above table except in a few cases where it has been separately returned by the mine owners. The total mineral production may therefore safely be valued at not less than £1,400,000.

#### CONDITION OF THE FIELDS.

The foregoing detailed description of the various mining districts shows them all in a most serious condition of very feeble activity or total stagnation except the recently resuscitated copper mines near the coast, and the tinfields. A very short examination of the gold-mining centres is sufficient to impress upon any observant visitor the inadequacy of the working trials that have been for the most part given to the reefs. The workings are nearly all very shallow, and very little driving and cross-cutting have been done as a rule, attention having been mostly confined to stoping out rich bunches of ore. Very few of the mines have had any machinery upon them for pumping water or raising and treating the ore, nearly all of the output of gold being the result of windlass work. The values in the reefs have doubtless been erratic, but when the bunches of rich ore followed from surface have given out there have been far too many cases of the mines being abandoned without any apparent effort having been made to search for similar bunches by systematic development. The reefs are often of very fair size, and mostly of a character to give considerable confidence in their permanency in depth. I could see no sufficient grounds at all for the pessimism very often expressed as to their carrying gold in depth, and for the belief that the gold in them is merely superficial, but on the contrary while there has, probably enough, been a good deal of superficial enrichment of the shallower oxidised portions of the reefs, it seemed to me that the ore from the deeper workings, often carrying gold associated with pyrites, copper pyrites, and stibnite, was of a very permanent type, belonging to the original substance of the reefs, and little if at all likely to have been affected by secondary enrichment. Though patchy distribution of the values in bunches and shoots will very likely at all times continue to characterise the reefs, there is little good reason for fearing that their systematic development in depth will not result in the discovery of good ore at frequent intervals.

The recorded returns of crushings to end of April, 1907, show that 79,718.62 tons of ore crushed in the two goldfields yielded



127,974.32 fine ounces of gold, or at the rate of 1.65 fine ounces per ton, not including the gold from specimens dollied, which is properly to be credited to the reefs also. This is an average value for the whole of these fields of £7 per ton of quartz crushed, which is an excellent return, especially when it is considered that it is the average over a large number of small contributing mines. As has been seen, however, district after district has languished or died, and in every case the causes have been the same, namely high costs of working under present conditions, and want of regularity in the values carried by the reefs. The latter of these causes can best be met by sufficiently extensive development to average the irregularities, but there has been too little of such work done in these fields to enable any reckoning to be formed yet of the extent to which the necessary development work would affect the general mining costs. This can only be found in each case by actual trial. The high costs of working are due to scarcity of timber and fuel, and great want of facilities in obtaining machinery, mining supplies, and all the ordinary necessities of life.

The high cost of timber and firewood is due to the scarcity of good forests in this goldfield, it being often necessary to cart the firewood 6 to 10 miles, and mining timber 10 to 50 miles or more. For most structural purposes Oregon timber carted from the coast is the cheapest available. Round mining timber for ordinary sets and props often costs up to 1s. per lineal foot, and firewood 35s. to 45s. per cord. The only possible cure for this drawback is a means of cheaply importing timber and fuel from the coast.

The want of facilities in obtaining goods of all sorts re-acts on costs of every kind. The cost of living is high and therefore wages must be high. Miners' wages are from £4 a week in the more accessible districts to £4 10s. and even £5 at Nullagine, and other sorts of labour in proportion. Beef and mutton are obtainable at fairly reasonable rates, though not so cheaply as might be expected in a pastoral district, but nearly all other foodstuffs have to be imported. Flour is retailed in Marble Bar at 13s. per bag of 50lbs., tea at 2s. to 2s. 6d. per lb., sugar at 5d. per lb., or 25s. per bag; tinned meats 1s. per tin or 11s. per doz. tins, rice 21s. per bag of 56lbs., tinned fruit 14s. per doz. or 1s. 3d. per tin, tinned milk 10s. per doz. At Nullagine foodstuffs are much dearer, and an unusual state of affairs was disclosed in that people were finding it actually cheaper to have small parcels of onions, eggs, potatoes, butter, and similar goods sent to them by parcel post from Fremantle than to purchase them from the local stores after being sent at freight rates in storekeepers' quantities by steamer and wagon or camels. Freights on goods from Port Hedland to Marble Bar by wagon or camel team run from £6 to £14 per ton, £9 being about an average figure for ordinary domestic supplies. To Nullagine is £6 to £8 more, making say on the average £17 a ton from Port Hedland or £19 a ton from Fremantle. Nearly all building materials are

imported, and I heard of as high as £14 a ton being the contract price for freight of timber and iron required at Marble Bar from Port Hedland. On heavy mining machinery, such as boilers, rates are very much above those ruling for ordinary freight.

Not only do the high costs of transport add greatly to the cost of all supplies, but there is also a really much more formidable obstacle to mining progress in the terrible loss of time involved in getting them from the coast. It takes three days for a light conveyance to go from Port Hedland to Marble Bar, a distance of 115 miles, the road being mostly sandy, and heavy wagons take eight to 12 days to do the same journey. From Marble Bar to Nullagine is 60 miles, taking the teams four to six days more. It is quite usual therefore for mining stores for the inland centres to be two or three weeks on the way from the coast, and as many things have to be sent for from Fremantle, the journey from which to Port Hedland takes a week, and steamers leave at weekly to fortnightly intervals, it is rarely possible to get them delivered on the mines in less than four weeks from the time of telegraphing for them, and quite frequently it takes six or seven weeks. When orders have to be sent by letter and there is necessary delay in getting them filled in Perth or Fremantle, as is often the case with orders to the factories and foundries, it may easily be over two months before the goods reach the mines. Any breakdown of important machinery which cannot be repaired locally is therefore liable to cause partial or total stoppage of the work of the mine for a very serious period. Delays of this sort and loss of time through struggling with makeshift methods of getting on without the proper appliances are often the cause of great increases in mining costs, far more important than the actual cost of the machinery or goods which are being waited for.

While railway communication between the fields and the coast would not entirely remove these disabilities by any means, it would go a very long way towards doing so, enabling goods to be carried into the interior at greatly reduced rates and minimising the loss of time in procuring supplies which has been so serious. It will also of course greatly facilitate travelling of persons, enabling people to go from the interior to the coast and *vice versa* in one day instead of three or four, and at much less cost.

#### MINING LOW-GRADE GOLD ORES.

With such high costs as have prevailed in the Pilbara fields it has been quite impossible to work any but the very best of the ore at a profit. The high average return above quoted of £7 a ton is only another way of expressing the same thing, no one having found it worth while to send the poorer stuff to the mills. It would be very much opposed to general mining experience, however, to infer from what has been done that the ore in the mines could be divided into two classes, rich ore

averaging £7 a ton and poor ore not worth touching at all, it being much more usual that there should be a gradation of value from the richest to the poorest, with, commonly, much more of the lower grades of value than of the higher. From my examination of the mines I see no reason for thinking that the reefs of the Pilbara fields will behave otherwise than usual in this respect, and would regard the 79,719 tons of £7 ore which have been crushed from them as very strong *prima facie* evidence that there are some hundreds of thousands of tons of say 30s. to 40s. ore left in the neighbourhood of the richer shoots. With improvements of mining facilities by railway communication much of this could be profitably handled.

#### MINING FOR BASE METALS, ETC.

It has been shown in the foregoing that besides gold the Pilbara district also contains good tinfields, and that good copper, silver, lead, and antimony ores have been found in several localities. The costs of realising copper ores have been well shown previously in the case of Mr. Bonner's parcel from North Shaw, and it is clear that ores from still more distant localities can only be exported at even higher cost. Copper ores are reported to have been found away in the eastern portion of the Pilbara Goldfield, to the east of the rabbit-proof fence, and it is obviously quite impossible for anything to be done with such mines while costs of working and of getting the ore to market are so prohibitive as now. Unless some of these mines turn out to be able to maintain smelting works of their own, the only hope of getting any return from the ore is by exporting it, and only the richest ore will now pay costs of doing this. Very few mines however are able to exist for long merely on the export of their richest ore, and the only hope of enabling the more inland base metal mines to be worked for any length of time lies in greatly improving the existing facilities of transport so as to give cheap carriage of ore to oversea markets and cheap working costs that will allow a much lower grade of ore to be shipped, until such time as the mines are able to support their own concentrating mills or smelting works.

The tin mines are in a rather better position than those of lead and copper in this regard, as the milling and concentration of tin ores is a comparatively simple and inexpensive process which produces a rich dressed product able to support high transport charges. The milling and dressing mills nevertheless must have rapid means of communication with foundries and central supplies of stores if they are to be maintained in the good working order necessary for cheap working costs.

Minerals of comparatively low initial value such as crude asbestos, mica, and ornamental stone, all of which exist in the Pilbara fields, are of course especially affected by costs of transport, there being no possibility of exporting them to a market unless the cost of carriage is kept down to a very low figure.



## RAILWAY COMMUNICATION AND ROUTES.

If, therefore, the Pilbara fields are to be developed as their record of production and their promise for the future warrant, it is absolutely necessary that they should be opened up by a railway from the coast. This is generally admitted by all who know the fields, but there is great diversity of opinion as to the best route to be followed. Three starting points on the coast have been seriously considered, Port Hedland, Balla Balla, and Point Sampson, and more than one route suggested from each.

One line has actually been surveyed, from Port Hedland southeasterly across the coastal plain for about 77 miles to Gorge Creek, where it reaches the edge of the mountainous country, thence along the north edge of the latter for about 18 miles to a pass to the east of the Doolena Gap, thence south 20 miles to Marble Bar, a total distance of 115 miles. From Marble Bar the survey has been carried on to Nullagine, passing on the north side of the Warrawoona range, crossing it between Warrawoona and Yandicoogina, and thence running south to Nullagine, a total distance of 180 miles from Port Hedland. This line passes through country which has not yet been proved to be metalliferous for the first 77 miles, but at this point would become of great benefit to the Lalla Rookh and North Pole fields, which lie about 25 miles to the south, and from Gorge Creek onwards would be in the most convenient position practicable for a line serving the unproved mountainous country to the north of a line connecting Lalla Rookh and Marble Bar, which, from its geological structure, is likely to be auriferous. At about 95 miles it can be reached from the Bamboo field in about 28 miles, a little farther south it passes close to Talga Talga, and at Marble Bar it meets the converging roads which centre there from Moolyella, Yandicoogina, Warrawoona, and Cooglegong. If then continued on to Nullagine it would serve Warrawoona, Yandicoogina, Nullagine, and the Middle Creek and Mosquito Creek Districts, following much the same route as the road from Marble Bar to Nullagine. Marble Bar is the existing distributing centre for these fields, and appears to be so for good geographical reasons. If the railway from the coast were only carried as far as Marble Bar it would still be very beneficial to the fields just mentioned, to all of which there are fairly good existing roads. The extension to Nullagine would be an immense help to Warrawoona, Nullagine, and Mosquito Creek fields, and would be almost a necessity for extensive working of the Nullagine conglomerates, but it is not of the same immediately vital necessity as the section to Marble Bar, and might be deferred for a time.

The second proposed route from Port Hedland is one running a more southerly course for about 50 miles to Poonthuna Pool and then turning almost due east to rejoin the first route at Gorge Creek. The detour increases the length of the line by about 17

miles. Its object is to bring the route nearer Wodgina, which could be reached in about 27 miles from it, and it would be of service to the tin-bearing district of Mt. York also. The patches of greenstone and schist country seen on the geological map at Cooke's Hill and to the south of Mt. Dove are likely places for mineral discoveries, though not as yet known to be valuable, and would be served very well. This route would run within 10 to 20 miles of the north-western edge of the mountainous but probably auriferous country lying north-east and south-west from Lalla Rookh, and would, therefore, be of direct service to a much larger extent of likely mineral country than the first one. The assistance it would afford to the known centres of Wodgina and Lalla Rookh, together with its good chances of opening mineral country at Cooke's Hill, Mt. Dove, and between Wodgina and Gorge Creek, have to be considered seriously as against the greater length of 17 miles which it involves in first construction, and for all time on freights to points further inland than Gorge Creek. As things stand at present there is not enough known mineral development to justify departure from the first direct route, but I am nevertheless strongly inclined to believe that the detour will prove to be the best solution of the difficult problem of giving the best service possible in this district of scattered mining centres.

Two other routes have been mentioned which are variations of the second one just described, namely, one southward from Poonthuna Pool to Pincunah Hill, and thence by North Shaw and Just-in-Time to Marble Bar, the other more directly from Poonthuna through the hills to Marble Bar. These routes are only feasible on the map, the country to be traversed being so rough and broken as to render them out of the question. Doubtless they are practicable if sufficient money were spent, but they would be terribly expensive, and need not be seriously taken into consideration in existing circumstances. The lines of railway, it must be recognised, must go round the big island of rough country shown in green on the geological map, and not through it.

A third route from Port Hedland would continue through Poonthuna Pool, pass west of Pincunah Hill, and run down the west side of the greenstone island to a point between Woodstock and Tambourah, where it would have to cross a narrow range of hilly country to reach the plains of the Upper Shaw. This crossing might be expensive work, but probably a practicable line could be got without very much trouble. The line would then best run as straight as possible towards Nullagine, which would be reached in about 170 miles, or 10 miles less than the northern route *via* Marble Bar. A long branch line would be required to reach Marble Bar and Moolyella *via* Warrawoona from this route. If instead of going from the crossing of the range near Tambourah directly towards Nullagine, the line were taken through Cooglegong and Just-in-Time to

Marble Bar, it would have a good deal of rough country to traverse and would be much longer than the northern route. No. 3 route would serve Wodgina, Tambourah, and Western Shaw fields well, would open likely country along the west side of the greenstone island, would suit the asbestos discoveries, and the Cooglegong and Shaw tin-fields, besides serving Nullagine as well as the northern route. The value of the country traversed is, however, much less, both according to records of production and present appearances of future success than of that which would be opened by the northern route, and on the evidence at present available the latter (route Nos. 1 and 2) is greatly preferable. From Wodgina onwards to Nullagine, however, this No. 3 route would be identical with proposed lines coming inland from Roebourne or Balla Balla.

The fourth route to be considered is from Balla Balla *via* Whim Creek, Mallina, and Station Peak to Wodgina, thence going on to Nullagine and Marble Bar on route No. 3, just described. It would have the advantage of passing through proved mineral country all the way. It would be about 180 miles to Nullagine, and 193 miles to Marble Bar *via* Corunna Downs and Warrawoona, which is probably the most practicable route. In many ways this is the most desirable railway line of all those proposed, but it would require a lot of expenditure in furnishing the terminus at Balla Balla with wharfage and other landing facilities to fit it for general traffic.

Route No. 5 from Point Sampson and Roebourne might run along the coastal plain to Whim Creek to join No. 4 there, but would more probably go by Croydon to join No. 4 near Station Peak, opening up a line of rather promising country that would not be served by the coastal line, but leaving the important Whim Creek field to be worked as at present through Balla Balla. These alternative routes would require, I think, to be actually surveyed and carefully estimated for before a choice could be properly made of one or the other. It is very possible that an expenditure at Balla Balla on improvement of shipping and landing facilities, of no greater amount than would be required to bring the line round by Whim Creek over and above the cost of its construction *via* Croydon, might make that port quite equal to the needs of the Whim Creek District. Sufficient data are not yet available for full consideration of this question.

The distance from Point Sampson to Nullagine *via* Whim Creek, Station Peak, Wodgina, and Tambourah, is about 225 miles, and to Marble Bar 218 miles; *via* Croydon it would be about five miles less. In the present state of the West Pilbara and Pilbara fields, along the routes both from Roebourne and Balla Balla there does not seem to me to be the same inducement to build a railway as there is for the Port Hedland routes, Nos. 1 and 2 above. The best



parts of the West Pilbara field so far worked are quite near the coast, and do not require railway communication with the same urgency as the inland fields. Improvement of the means of landing and shipping cargo at Point Sampson by connecting the jetty there with the Roebourne-Cossack tramway would go a long way towards removing the disabilities under which the mines of the Roebourne District suffer, and the railway would not improve their condition much until we come to such as are in the more outlying fields like Croydon and Station Peak. A line terminating at Balla Balla would suit the interior fields even better than one ending at Point Sampson, if equal shipping facilities were provided.

*Terminal Port.*—The choice of the best route for opening up these goldfields depends very greatly on the relative suitability of the ports proposed as coastal starting points. It seems to me that in many ways this is the most important question of all, the securing of a good port being of much greater consequence than getting the shortest length of railway construction. A railway is a very permanent work, and once its starting point is fixed there will be very little chance of ever reconsidering the question, as vested interests will soon be created which will render a change practically impossible. It is therefore incumbent on us to look ahead as well as at immediate requirements, and try if possible to secure a port which can be progressively improved as time goes on so as to meet expansion of traffic.

Port Hedland is at present by far the best of the three ports that are available, inasmuch as the coastal steamers come up to a wharf in a well-protected, land-locked basin where they can take on board and discharge cargo with ease and despatch. Railway trucks could be run right alongside the vessels and there is plenty of room for extension of the wharves. By dredging, as the needs of the port require it, it will be possible to greatly enlarge the deep water basin, and with the aid of walls regulating the currents to straighten the tortuous channel by which the harbour is entered. So far as the land-locked portion of the harbour is concerned there seems every possibility of improving it from year to year so as to become in time a very fine harbour. But there seems very little chance of its ever being anything but a tidal port, as the bar outside the entrance is a wide series of hard reefs, the channels through which are only safely navigable when the tide is well up. There does not seem much possibility of effecting any considerable improvement in this respect, the reefs being too extensive and far out to sea to be dealt with. There is, however, over 20 feet of rise of the tide, and at high water the entrance is not formidable. Many well-known ports are tidal ones, however, and the inability to enter Port Hedland at all times of the tide, though a drawback to it, need not be regarded as a very serious detriment.

The shores of the Port Hedland steamer basin are very low-lying, being only a few feet above high water mark, and it is somewhat doubtful what protection they would afford to vessels if the port were struck by one of the fierce cyclonic storms that every now and then occur on this part of the coast. If a vessel could not get out to sea in time, through the tide not suiting, it would have to endure the storm as best it might at its anchors and moorings in the basin, with practically no protection from the wind, though a good deal sheltered from the worst force of the seas. There seems to be considerable doubt on the part of nautical men as to the security of shipping caught in the harbour in such a storm, and in this regard the inability to get promptly out to sea at any time does seem to be a serious drawback to the port.

The port at Balla Balla at present consists of a small tidal creek from which the water runs almost entirely out at low tide, but which is navigable for small craft when the tide is high. There is a small jetty, from which ore is lightered out to steamers lying outside, and which serves to receive incoming goods. The coastal steamers lie outside the mouth of the creek in a somewhat narrow channel of deep water lying between the north end of Depuch Island and the mainland. This anchorage is well sheltered on the south side by Depuch Island, which is a high rugged rocky hill of greenstone. There is deep water right in along the channel to the anchorage, but this is still some distance out from the shore. Nautical opinion seems to favour this as one of the best ports on the N.W. Coast, there being good shelter in most winds and clear ingress from and egress to the open sea at all times of the tide. There seems, however, to be a deficiency of information as to what is possible to be done in the way of making it a port fit to be the terminus of a railway, and I understand further surveys are now being undertaken to ascertain what can be done. The best landing is said to be on Depuch Island, which would necessitate the connection of this with the mainland by a long causeway and bridge in order that railway trucks should run to the steamers' sides. I have not been able to ascertain if projects of running out long jetties from the mainland side are at all feasible. It is fairly certain that very large expenditure would be required to enable the steamers to lie alongside any railway wharf. From what I have been able to learn about this port, however, there seems a better chance of eventually making it a really good one than either Port Hedland or Point Sampson, and the results of the surveys now being carried out will therefore be very important, for, should they confirm this opinion, it would be well worth consideration whether it would not be better to face the necessary expenditure here than to go on spending money at Port Hedland with only a tidal port to look forward to in the end. The possibility of working the port for a time with a tidal

railway jetty on the mainland, and a steam lighter service between it and the ocean-going steamers has also to be considered, as it might be feasible to begin in this way at not too great a cost and go on with a larger scheme later on. At present no conclusion can be come to for want of sufficient data.

At Point Sampson a fine jetty has been made to deep water, and the coastal steamers can come alongside it at any time of the tide. It would, however, require much strengthening and widening to make it fit for a terminal railway wharf. This jetty is very open to the sea, but I have been informed that there are usually but few days in each year on which vessels would be prevented by heavy weather from mooring alongside the jetty. There is good open water for coming in and getting out, and in threatening weather steamers could put safely out to sea at any time. How far the jetty itself could resist the full force of a cyclonic storm has not yet been demonstrated by actual experience, and there is much difference of opinion on the matter. It is certainly much more exposed to the full force of the seas than would be the jetties at either Balla Balla or Port Hedland, and would have to be enormously strong to be able to successfully resist the terrible weather which sometimes strikes the North-West coast. Whether the present timber jetty is able to do so or not may perhaps be questionable, but there is no doubt that if required the resources of modern engineering in steel and ferro-concrete structures are capable of dealing with even the most violent seas.

At present the Point Sampson jetty is mainly used for shipment of cattle and sheep, there being no practicable approach to it on the land side for loaded vehicles. It could, however, be easily connected with the Roebourne-Cossack tramway by a branch line from this, and there is no engineering difficulty in the way of starting a railway from it. For immediate requirements of the Roebourne district the connection with the Cossack tramway is urgently required, the large expenditure already incurred in building the jetty being practically useless so far as goods are concerned until the connection is made. Goods from the steamers are sometimes now put on Point Sampson jetty to be lightered thence to Cossack, and ore brought out of Cossack Creek by the lighters is sometimes lifted from the Point Sampson jetty by the steamers, but except for convenience of deposit when direct lightering is not possible it is of little use except for live stock. The Cossack harbour is a tidal one, only suitable for small craft.

So far as an immediately workable terminal port for the railway is concerned it will be seen therefore that all the advantage lies with Port Hedland, and unless Balla Balla turns out to be much more easily made workable than at present anticipated, it is obvious



that large expenditure will be required both there and at Point Sampson to provide the facilities required at a railway terminus.

*Railway Route Recommended.*—While the routes from Roebourne and Balla Balla to Nullagine *via* Wodgina present many advantages in the matter of opening up likely country, they are the least suitable for the service of the parts of the Pilbara goldfield which have been the most productive hitherto, and which have therefore the first claim to be provided with railway communication. They are also the longest routes, and so would be the most costly lines to construct and work. Lastly they start from ports which would require much larger immediate expenditure upon them to fit them to be the starting point of the railway than does Port Hedland, while there seem better possibilities of eventually making the latter a protected and safe harbour than at either Balla Balla or Point Sampson, though these both have the advantage of a better get-away to sea. The No. 1 route, that already surveyed, from Port Hedland to Marble Bar, therefore seems the one that must be recommended as the best according to present knowledge, but though as yet there is no strong justification, except the Wodgina district, for the detour to the south constituting route No. 2, the extra chances which it gives of opening mineral country go far to counterbalance the increased length. As a matter of personal belief I favour route No. 2 rather than No. 1, but must admit that my reasons for the preference are more speculative than demonstrable. If there were any reasonable hope of serving the Wodgina district in the near future by a line from Balla Balla or Roebourne opening the West Pilbara fields, it would be best to keep to Route No. 1, but as the next most important line in this district to that from Port Hedland to Marble Bar is its extension from Marble Bar to Nullagine or Mosquito Creek, it is hardly likely that a third railway can come within practical politics for a long time, and the detour of No. 2 route seems the best compromise.

*Traffic for Railway.*—It is very little use at present trying to make any estimate of the traffic the railway will have on the basis of present population and amount of goods carried by teams. There are some 1,200 people in the country served by the line, and the monthly import of stores of all sorts into Marble Bar is stated to be about 120 tons. These figures of themselves obviously do not justify a railway, but when we look at field after field lying dormant for want of facilities for development, it is equally obvious that the country is capable of supporting a large population, able to make a railway pay handsomely.

I have not dwelt in this report at all upon the pastoral resources of the Pilbara fields, but they are very great, and the number of sheep and cattle raised and the acreage of land enclosed in stock paddocks is very rapidly increasing. The general prosperity of

pastoralists in this region is very marked, and there seems no doubt possible as to the great value to the State of the pastoral industry in it. One notable effect of the construction of a railway to Marble Bar will be that station country can be taken up still further back, beyond what is at present the workable range from the coast. From information gained during the trip I have every reason to believe that there will be considerable inland expansion of pastoral holdings as soon as the railway is decided upon.

I have, etc.,

A. MONTGOMERY, M.A., F.G.S.,

State Mining Engineer.





To end of— 1906 1907	North Shaw Do.	7.53 ..	567.06 ..	351.45 ..	674.72 ..	7.53 ..	567.06 ..	351.45 ..	674.72 ..
To end of— 1906 1907	Shark's Do.	145.08 ..	19.37 ..	6.00 ..	33.00 ..	145.08 ..	19.37 ..	6.00 ..	33.00 ..
To end of— 1906 1907	Shaw River Do.	.. ..	.. ..	101.00 ..	49.63 ..	.. ..	.. ..	101.00 ..	49.63 ..
To end of— 1906 1907	Talga, Talga Do.	50.26 ..	152.82 ..	779.15 ..	1,496.23 ..	50.26 ..	152.82 ..	779.15 ..	1,496.23 ..
To end of— 1906 1907	Tanbourah Do.	.. ..	64.65 ..	2,077.75 ..	2,536.88 ..	.. ..	64.65 ..	2,077.75 ..	2,536.88 ..
To end of— 1906 1907	Warrawoona Do.	44.30 ..	338.15 ..	7,456.09 ..	16,211.63 ..	44.30 ..	338.15 ..	7,456.09 ..	16,211.63 ..
To end of— 1906 1907	Western Shaw Do.	.. ..	4.77 ..	1,221.00 ..	930.73 ..	.. ..	4.77 ..	1,221.00 ..	930.73 ..
To end of— 1906 1907	Wyman's Well Do.	.. ..	47.68 ..	292.40 ..	872.07 ..	.. ..	47.68 ..	292.40 ..	872.07 ..
To end of— 1906 1907	Yandicoogina Do.	.. ..	373.36 ..	2,768.25 ..	5,718.33 ..	.. ..	373.36 ..	2,768.25 ..	5,718.33 ..
To end of— 1906 1907	District generally Do.	5,918.72 95.34	217.05 ..	237.95 ..	1,120.77 25.19	6,014.06 ..	217.05 ..	237.95 ..	1,145.96 ..
	Total	..	..	..	..	6,270.17 ..	2,224.37 ..	42,602.13 ..	71,848.56 ..

## GOLD PRODUCTION OF PILBARA GOLDFIELD—continued.

As reported to the Mines Department to 30th April, 1907.

Mining Centre.		Alluvial.		Dollied and Specimens.		Ore treated.		Gold therefrom.		Alluvial.		Dollied and Specimens.		Ore treated.		Gold therefrom.	
		Fine ozs.		Fine ozs.		Tons, (2,240lbs.)		Fine ozs.		Fine ozs.		Fine ozs.		Tons, (2,240lbs.)		Fine ozs.	
NULLAGINE DISTRICT.																	
To end of— 1906 1907	Elsie ..	..	..	..	..	428.25	..	1,340.70	..	..	..	..	..	428.25	..	1,340.70	..
	Do. ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
To end of— 1906 1907	Mosquito Creek ..	..	..	166.47	..	6,354.49	..	10,289.54	..	..	..	166.47	..	6,553.49	..	10,667.16	..
	Do. ..	..	..	..	..	199.00	..	377.62	..	..	..	..	..	..	..	..	..
To end of— 1906 1907	Nullagine ..	104.70	..	105.19	..	14,096.40	..	21,754.99	..	104.70	..	105.19	..	14,191.90	..	21,945.41	..
	Do. ..	..	..	..	..	95.50	..	190.42	..	..	..	..	..	..	..	..	..
To end of— 1906 1907	20-Mile Sandy ..	..	..	14.36	..	2,807.60	..	6,723.11	..	..	..	14.36	..	2,876.60	..	6,815.54	..
	Do. ..	..	..	..	..	69.00	..	92.43	..	..	..	..	..	..	..	..	..
To end of— 1906 1907	District generally ..	3,902.02	..	22.50	..	38.50	..	2,517.87	..	3,972.12	..	22.50	..	38.50	..	2,517.87	..
	Do. ..	70.10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total ..		..	..	..	..	..	..	..	..	4,076.82	..	308.52	..	24,088.74	..	43,286.68	..
GRAND TOTAL PILBARA GOLDFIELD		..	..	..	..	..	..	..	..	10,346.99	..	2,532.89	..	66,690.87	..	115,135.24	..
																= 128,015.12 Fine ozs.	

## APPENDIX.

## CHRYSOTILE ASBESTOS FROM NEAR COOGLEGONG.

Referring to the description by Mr. P. C. Riches, of the Pilbara Asbestos Company's mine, quoted in the foregoing report, the following are his notes on samples forwarded with his report and the report of the Government Mineralogist and Assayer upon them :—

## MR. RICHES' REPORT.

No. of Bag.	Remarks.
1	Taken from pot-hole at North-East end of lode.
2/10	Taken from shaft.
7	Apparent hanging wall.
8	Apparent foot wall.
11	Average sample of dump.
12	Lode 12 inches wide, going 15 per cent. fibre, depth from surface 1 foot
13	Lode 18 inches wide, going 15 per cent. on surface.
14	Lode 2 feet wide, going 20 per cent., depth from surface 1 foot.
15	Lode 2 feet wide, going 20 per cent. fibre, depth from surface 1 foot, much decomposed.
16	Lode 18 inches wide, going 20 per cent., fibre depth 2 feet from surface, much decomposed.
17	Lode 3 feet wide, going 15 per cent., fibre depth from surface 18 inches
18	Width of lode 3 feet, going 15 per cent. fibre, depth from surface 2 feet.
19	Lode 2 feet wide, going 20 per cent. fibre, depth from surface 2 feet.
20	Lode 8 inches wide, going 20 per cent. fibre, depth from surface 6 inches
21	Lode 3 feet wide, going 20 per cent. fibre, depth from surface 18 inches much decomposed.
22	Sample of diorite bar.
23/24	Surface samples.
25/26	Specimens of long fibre. Also two large specimens of lode showing occurrence of Asbestos veins.

## GOVERNMENT MINERALOGIST AND ASSAYER'S REPORT.

I have examined the 28 samples of asbestos and associated rocks from Tamboorah District with the following results :—

3653 No. 1.—Weight 7 ozs. Rock and fibre, both much broken and weathered. No commercial value.

3654, No. 2.—Weight 1lb. 13ozs. Asbestos vein  $2\frac{1}{2}$  to  $2\frac{3}{4}$  inch wide, interrupted by central vein. Total first quality fibre about 95 per cent. Length of fibre,  $\frac{1}{2}$  in. to  $1\frac{1}{2}$  in., average about  $1\frac{1}{4}$  in.

3655, No. 3.—Weight 1lb. 15ozs. Serpentine with veins of asbestos Fibre about 50 per cent. of whole, mostly first quality, but a little ironstained. Veins  $\frac{1}{2}$  in. to  $2\frac{1}{2}$  in., with partings. Fibre,  $\frac{1}{2}$  in. to  $1\frac{1}{2}$  in., average  $\frac{3}{4}$  in.

3656, No. 4.—Weight 1lb. 8ozs. Asbestos vein with adhering rock Yield of fibre about 80 per cent. Vein, 2 in. to 3 in. Fibre,  $\frac{1}{2}$  in. to  $1\frac{1}{2}$  in.; average,  $1\frac{1}{4}$  in.

3657, No. 5.—Weight 12 ozs. Broken fibre from vein of about 3 in. Partly discoloured and weathered. Length  $\frac{1}{2}$  in. to 3 in.; average, about  $1\frac{1}{2}$  in.



- 3658, No. 6.—Weight 1lb. 13ozs. Green serpentine with veins of asbestos. Fibre about 60 per cent. Veins  $\frac{3}{4}$ in. and less up to  $1\frac{1}{4}$ in.; fibre up to 1in., and of varying quality. Average length about  $\frac{3}{4}$ in.
- 3659, No. 7.—Weight, 1lb. 13ozs. Purplish serpentine with one or two very narrow veins of asbestos. Under the microscope this rock is seen to be composed of massive structureless serpentine with very numerous inclusions of black and brown iron ore.
- 3660, No. 8.—Rock. Serpentine still preserving some of the structure of the original rock in the shape of partly altered olivine crystals and grains of ilmenite with leucoxene.
- 3661, No. 9.—Weight, 1lb. 9ozs. Green serpentine with numerous small veins of asbestos. Yield, about 50 per cent. of fibre, up to  $\frac{3}{4}$ in. in length.
- 3662, No. 10.—Weight, 1lb. Asbestos vein with adherent serpentine. Width of vein,  $2\frac{1}{4}$ in. to  $2\frac{1}{2}$ in. Fibre about 85 per cent. Length,  $\frac{3}{4}$ in. or less up to  $2\frac{1}{4}$ in.; average,  $1\frac{1}{4}$ in.
- 3663, No. 11.—Weight, 2lbs. Green and purple serpentine, showing no structure under the microscope, with veins of asbestos. Sample much broken. Yield, about 25 per cent. Veins from threads up to 1in. Fibre, up to  $\frac{3}{4}$ in.; average, about  $\frac{3}{4}$ in.
- 3664, No. 12.—Weight, 1lb. 8ozs. Much weathered and fractured asbestos with a little rock.  $3\frac{1}{2}$ in. vein represented. Too much weathered to be of value.
- 3665, No. 13.—Weight, 9ozs. Weathered serpentine with numerous veins of asbestos up to  $\frac{3}{4}$ in. in width. Considerably weathered and probably of little value.
- 3666, No. 14.—Weight, 10ozs. Green serpentine with veins of fibrous and sub-fibrous material. Suitable only for preparation of asbestic.
- 3667, No. 15.—Weight, 11ozs. Much weathered and ironstained asbestos with a little rock.— $1\frac{1}{2}$ in. vein represented. Valueless.
- 3668, No. 16.—Weight, 1lb. 10ozs. Serpentine with many weathered and stained veins of asbestos up to  $1\frac{1}{2}$ in. in width. Fibre,  $\frac{1}{2}$ in. or less up to  $\frac{3}{4}$ in.
- 3669, No. 17.—Weight, 1lb. 6ozs. Serpentine with veins of asbestos up to  $\frac{3}{4}$ in. Yield, about 30 per cent. Fibre partly discoloured. Length, up to  $\frac{3}{4}$ in.; average  $\frac{1}{2}$ in. to  $\frac{3}{4}$ in. Rock shows a reticulated structure under microscope, and is evidently an altered olivine rock.
- 3670, No. 18.—Weight, 1lb. 7ozs. Serpentine with veins of asbestos. Yield, about 40 per cent. Veins, threads up to  $1\frac{1}{2}$ in. Fibre, mostly under  $\frac{1}{2}$ in., and of inferior quality.
- 3671, No. 19.—Weight, 13ozs. Serpentine, with veins of discoloured and inferior asbestos, with fibre up to 2in.
- 3672, No. 20.—Weight, 12ozs. Asbestos, with a little adherent rock. Fibre much weathered and discoloured. Veins, up to 2in.; fibre, up to  $1\frac{1}{4}$ in.; average, about  $\frac{3}{4}$ in.
- 3673, No. 21.—Weight, 13ozs. Much weathered and ironstained asbestos from vein about 2in. Average length of fibre, 1in.
- 3674, No. 22.—This rock appears to be the least altered of those in the series. It consists largely of serpentine, and appears to approach in character the serpentinised augite-picrites of some parts of Cornwall.
- 3675, No. 23.—Weight, 2lbs. 2ozs. Serpentine and asbestos veins, one 2in. in width. Yield of fibre, 30 per cent., mostly 2in. in length. The rock in this sample appears to have a felted structure, and may, therefore, be used for the preparation of asbestic.
- 3676, No. 24.—Weight, 1lb. 8ozs. Similar to last, but more weathered. Greatest length of fibre 1in.
- 3677, No. 25.—Weight, 2lbs. 8ozs. First grade asbestos with a little adherent rock. Vein  $5\frac{1}{2}$ in. to  $6\frac{1}{2}$ in. wide with partings. Fibre up to 5in.
- 3678, No. 26.—Weight, 1lb. 14ozs. First grade asbestos with a little adherent rock. Vein about 6in. to 7in., with partings. Fibre up to 4in.; average 2in.

3679, No. 27.—Weight, 24lbs. Large block of green serpentine, with numerous small veins of asbestos. Proportion of fibre by measurement, 25 per cent. Veins up to 2in. ; fibre up to  $\frac{1}{4}$ in. ; average about  $\frac{1}{2}$ in.

3680, No. 28.—Weight, 7lbs. 9ozs. Smaller block similar to last. Proportion of fibre by measurement, 21 per cent. Length up to  $\frac{1}{2}$ in. ; average  $\frac{1}{4}$ in.

The asbestos in all these samples is of the chrysotile variety. It will not be out of place to re-quote here the analysis of a typical sample from this locality made some little time ago.

Silica	42.98
Magnesia	39.92
Manganese protoxide	Trace
Iron protoxide	.24
Iron peroxide	1.68
Alumina	.44
Water above 100°	12.88
Water at 100°	1.94
	<hr/> 100.08 <hr/>
Sp. gr.	2.37

Samples 27 and 28 are of especial interest as showing that the mode of occurrence is identical with that in other asbestos mines throughout the world, the fibrous serpentine (asbestos) occurring in numerous irregular veins in an intrusive mass of serpentine rock. The original rock, of which this is the altered form, may have been an augite-picrite.

The veins in the samples submitted have usually an anastomosing habit, and vary from 1 $\frac{1}{2}$ in. or less, up to 7in. in width, but the length of the fibres is almost always less than the width of the veins for two reasons :—

- (a.) They appear to have grown from both sides of the fissure at once, and to have met along a plane coated with non-fibrous material.
- (b.) After their growth was complete, minute movements in the walls have given rise to planes along which the fibres are kinked and liable to be broken on handling.

In spite of this, the samples submitted contain a high proportion of asbestos of excellent quality over half an inch in length, which would be in Canada classed as No. 1 and No. 2 grades, whilst there appears to be a certain proportion of similar fibre of exceptional length which should command exceptional prices.

(Sgd.)

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Mineralogist and Assayer.













UNIVERSITY OF ILLINOIS-URBANA



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